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A HYDROGEOLOGIC INVESTIGATION OF CHLORINATED HYDROCARBON CONTAMINATION AT THE RANNEY COLLECTOR WELL

VILLAGE OF ENDICOTT, NEW YORK

FINAL REPORT

GEOTECHNICAL SERVICES SECTION

APRIL, 1984

New York State/Department of Environmental Conservation

A Hydrogeologic Investigation of Chlorinated Hydrocarbon Contamination at the Ranney Collector Well, Village of Endicott, New York

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Eugene Kudgus, Village of Endicott
Allan Randall, U.S.G.S.
Edward Bogden and Kenneth Markussen, NYSDOH
Robert Denz, Broome County Health Dept.

This report would not have been possible without the attentive efforts of Ms. Jeri Vrooman.

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I. Introduction

In November, 1982 routine sampling at the Village of Endicott's Ranney production well indicated the presence of vinyl chloride (chloroethene). A preliminary investigation was conducted by Eugene Kudgus, Superintendent of Public Works for the Village of Endicott, to immediately address the problem of vinyl chloride contamination and to respond to the concerns of the Broome County Health Department and the NYS Department of Health. As a result of the study, the Village and the Health Department requested that a hydrogeologic study be conducted to aid in assessing the impacts of the contamination. In April, 1983 the NYS Department of Environmental Conservation agreed to provide technical assistance to the Village of Endicott for the purpose of conducting the incident response study.

The result of this agreement was the implementation of a Level III investigation. This is the most intensified study outlined in Department ground water contamination response guidelines. It involves a source investigation and a field intensive hydrogeologic study resulting in a remediation plan and design.

The goals of the hydrologic study were to identify the extent of ground water contamination in the vicinity of the Ranney collector well, determine the source of contamination and formulate a remediation plan to minimize the effects of contamination on the Village of Endicott's water supply.

The Ranney collector well is a significant source of water for the Village of Endicott and provides the major portion of the water supply. The quantity of water derived from this well cannot be replaced by existing wells in the Village water system. Furthermore, the cost of replacing a well of this capability is beyond the financial ability of the Village. Continued operation of the Ranney collector well is imperative to provide a potable groundwater supply to the residents of Endicott. The threat of groundwater contamination that may lead to closing the well must be addressed without delay. This report is an analysis of current contamination problems and presents possible remedial efforts. Because of the need to maintain this source of water supply a high priority has been placed on this aspect during all phases of the study.

II. History

A. Ranney Collector Well

The Ranney collector well was installed in 1948 by the Ranney Water Collector Corporation, a predecessor of the present day Ranney Corporation. It has been in continuous use since 1950 at various production levels ranging from 3500-7000 gallons per minute (gpm). The present well production level is approximately 3700 gpm.

The Ranney collector well consists of a 13 foot inside diameter caisson extending down from the pump house floor 108.5 feet. The bottom elevation of the caisson is 720.25 feet above mean sea level (MSL) (Figure 1). Twenty three 8 inch screened laterals of various lengths are projected horizontally from the caisson in four tiers (Figure 2). The lengths of the laterals were determined by the difficulty in projecting them during installation. Large boulders block many laterals from being extended to the desired length.

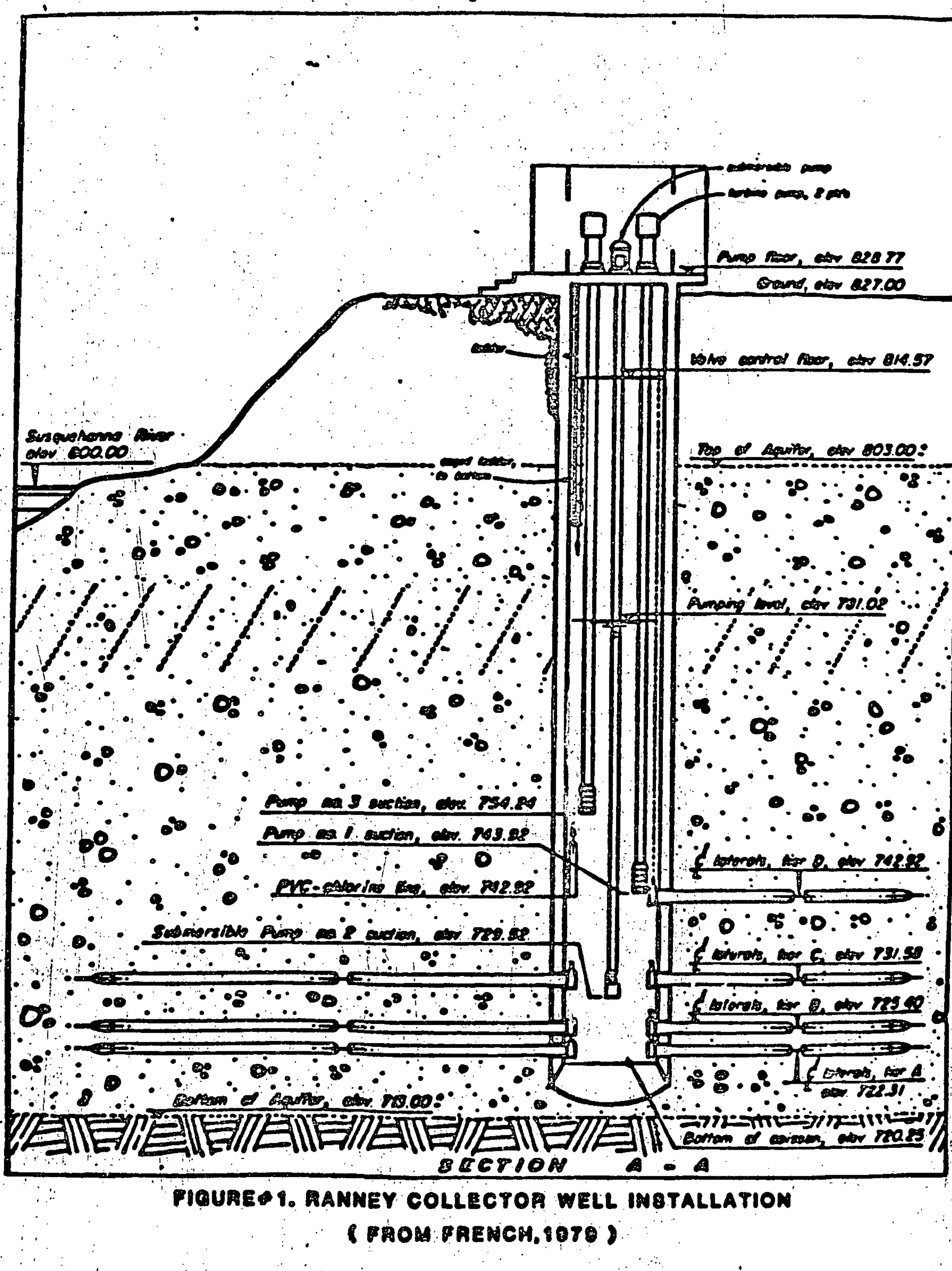
An analysis of flow contributions from each lateral was conducted as a portion of the 1979 well inspection (Table 1). This revealed a very poor distribution of flow between the twenty three laterals. Seven laterals contribute eighty three percent of the flow, nine laterals have no flow and four laterals have a cumulative flow of less than two percent.

The Ranney collector well is very efficient and creates a complex groundwater flow pattern. Many factors influence the flow distribution within the collector. For the purposes of this contamination study it was not necessary to define the individual components which determine the flow distribution within the tiered lateral system.

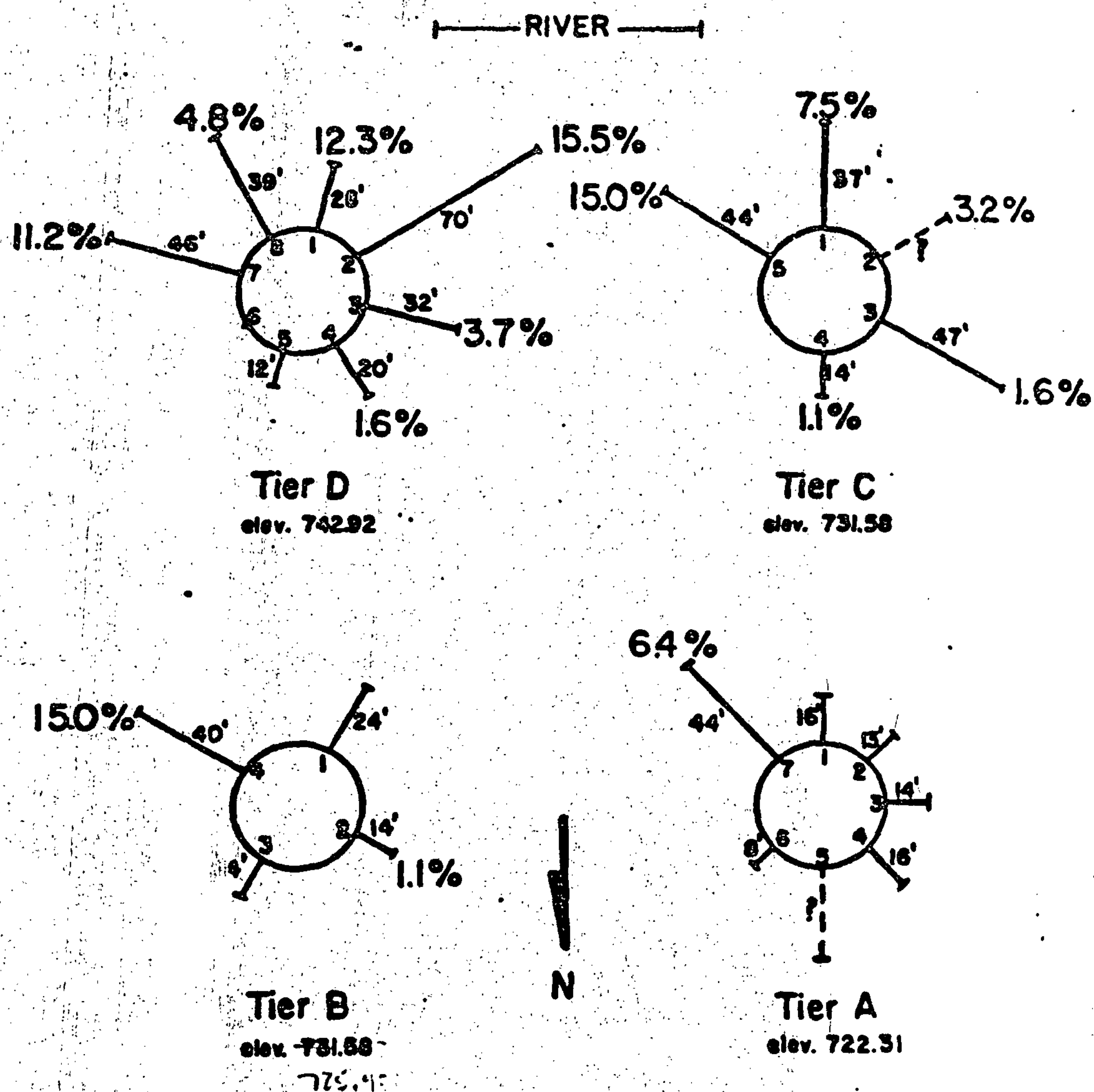
B. Contamination

In December, 1980, water surveillance samples collected by the NYSDOH revealed detectable quantities of chlorinated organics in the Village of Endicott's Ranney collector well. Subsequent sampling was conducted by the NYSDOH in January, May, and July, 1981, February, September, November, and December, 1982, and the results showed the occasional low level presence of certain volatile organic chemicals. NYSDOH notified Village officials of the low levels of organic contaminants in their public water supply, and a meeting was held at the NYSDOH regional office in Syracuse with local officials and NYSDOH personnel to discuss the implications of the contamination.

The NYS ground water standards and limitations are established in Title 6 of the NYSDEC, Official Compilation of Codes, Rules and Regulations, Part 703 (Appendix A). Two of the organic chemicals which have been found in samples from the Ranney well are included in Part 703. These chemicals are vinyl chloride and trichloroethylene in concentrations of 3 and 2 parts per billion (ppb), respectively. The standards established by these regulations are 5 and 10 ppb, respectively. In reference to chemicals not included in this list, the NYSDOH has issued a guideline that no drinking water shall contain more than 50 ppb of any organic chemical or 100 ppb of total organic chemicals, and for vinyl chloride the guideline is 5 ppb. In light of this criteria, vinyl chloride is the most critical of the contaminants found in the vicinity of the Ranney well.



FIGURE#1. RANNEY COLLECTOR WELL INSTALLATION
(FROM FRENCH, 1979)



FIGURE#2. ORIENTATION OF LENGTHS OF LATERALS, SHOWING PERCENTAGE OF FLOW CONTRIBUTION FROM EACH

Table No. 1

Percentage of Flow from Each Lateral
at a Discharge Rate of 4100 GPM

Lateral Number	Flow Percentage
A-1	0
A-2	0
A-3	0
A-4	0
A-5	0
A-6	0
A-7	6.4
B-1	0
B-2	1.1
B-3	0
B-4	15.0
C-1	7.5
C-2	3.2
C-3	1.6
C-4	1.1
C-5	15.0
D-1	12.3
D-2	15.5
D-3	3.7
D-4	1.6
D-5	0
D-6	0
D-7	11.2
D-8	4.8

Due to the high levels of vinyl chloride (with respect to DOH guidelines) Edward P. Bogden, of the NYSDOH Syracuse office, recommended immediate action be taken to determine quantities of vinyl chloride in the distribution system. The Village of Endicott proposed a sampling plan for individual laterals and the installation of an aeration system to decrease the quantities of vinyl chloride entering the water distribution system. In addition, samples were obtained from various points within the distribution system.

Samples from laterals D2 and D3, projected in a westerly direction, contained 17 to 20 ppb vinyl chloride respectively. The sample results indicated that significant quantities of vinyl chloride were transmitted to the Boswell Hill and Robble Hill pump stations. Little reduction in vinyl chloride concentrations occurred during distribution throughout the system. It was determined that the most practical short term method of decreasing vinyl chloride concentrations in the water supply was to install aeration equipment in the Ranney well. Due to their volatile nature, the contaminants would be stripped from water and discharged with the compressed air. A compressor and air diffusion equipment was installed and operational by March 9, 1983.

Since the installation of this equipment, quantities of vinyl chloride have not exceeded 5 ppb. Most weekly samples range from 2 ppb to nondetectable quantities. Air stripping of vinyl chloride in the caisson may have been an effective and efficient method of reducing concentrations of vinyl chloride in the Village water supply, however additional raw water analyses would be necessary to prove that initial concentrations were necessarily higher than those observed after aeration.

C. The Hydrogeologic Study

In April, 1983 NYSDEC initiated an incident response study. The first phase of this study included a literature search to determine the existence of all pertinent hydrogeologic data and the location of possible sources of contamination.

Information from approximately forty wells and test borings located within a 3500 foot radius of the Ranney well has been gathered. Most of these are located to the west and northwest of the Ranney well. Selected wells are discussed in the Site Geology section of this report, and their logs are located in Appendix B. Locations and logs of the other wells and borings are contained in Randall (1972). Six of these wells were sampled previous to the drilling phase of the trackdown study.

Ground water samples were analyzed by the NYSDOH laboratory in Albany using EPA method 601. The method detects 29 priority pollutant chemicals at a detection limit of 1 ppb. A complete list of parameters is in Appendix C. Five of the six wells sampled had no detectable quantities of priority pollutants as analyzed for in EPA method 601. These wells include the two flood relief wells, the Tier #1 Stop well, the golf course well and the well located at Hancor Industries. Locations of these wells are shown on Figure 3. The Kelley well, located approximately 100 feet to the northwest of the Ranney well, contained 6 ppb vinyl chloride when tested on May 10, 1983. In addition, chloroethene, 1,1-dichloroethane and trans-1,2-dichloroethene were detected at concentrations of 4,3, and 12 ppb, respectively.

KEY TO FIGURE 3

● Wells that provided geologic, hydrologic, and water quality data (logs in Appendix B)

B-1 - B-11 - DEC monitoring wells

K - Kelley well

O Test borings (logs in Appendix B)

TB - Existing borings (logs from Randall, 1972, in Appendix B)

B-7 - DEC boring

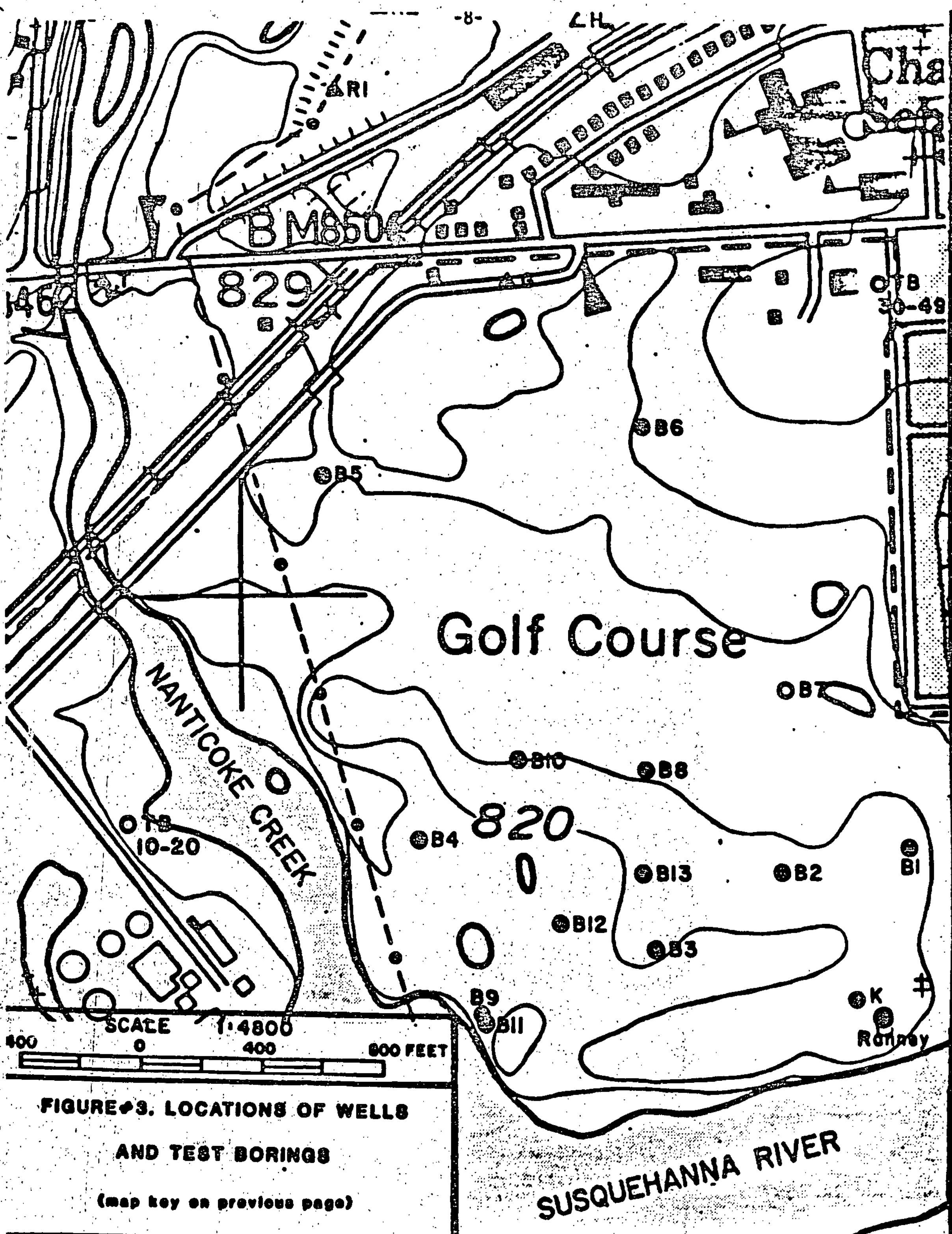
▲ Wells that provided water quality data (no logs available)

T - Tier One Stop

H - Hancor

R1 & R2 - Flood Relief Wells

G - Golf course well



FIGURE#3. LOCATIONS OF WELLS AND TEST BORINGS

(map key on previous page)

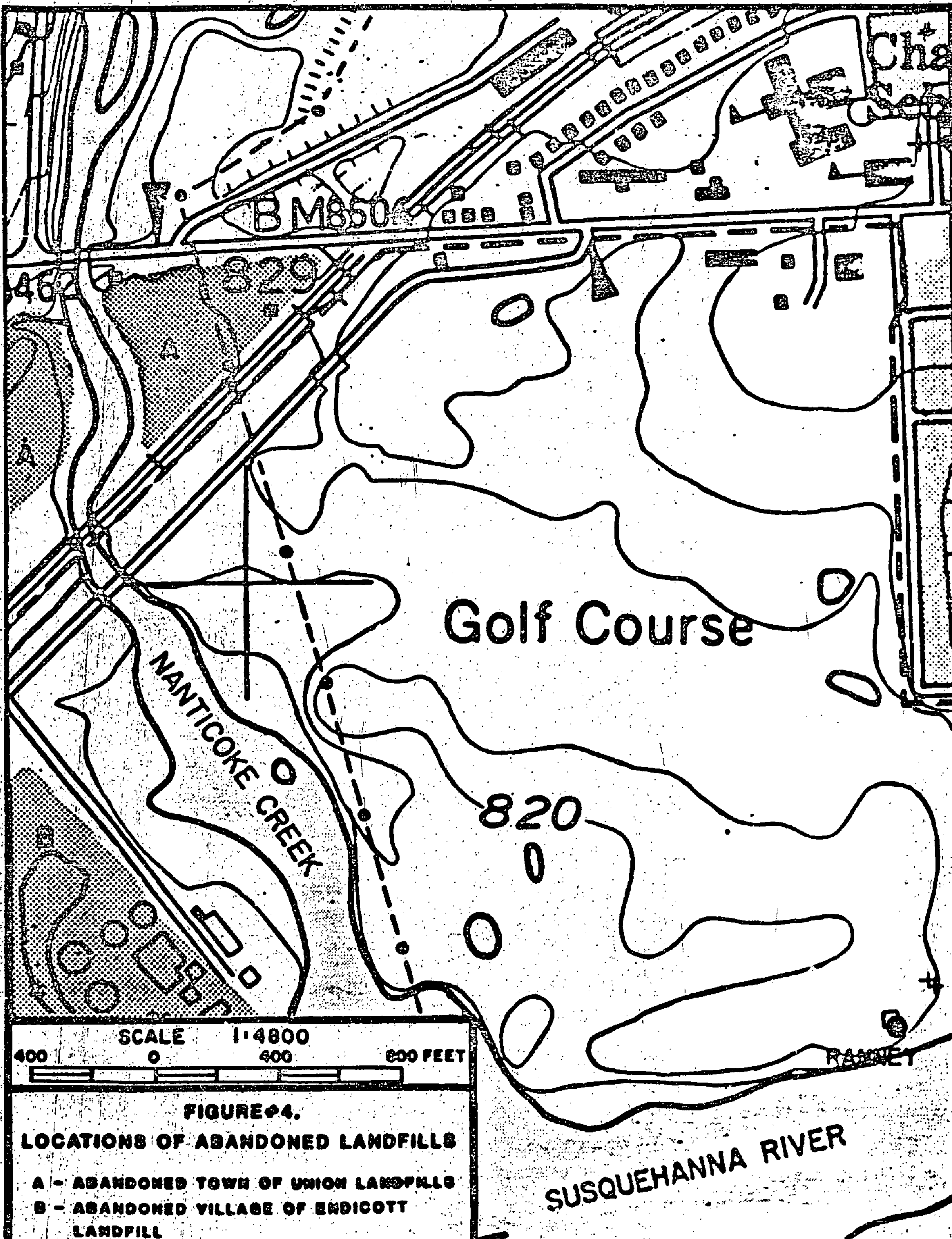


FIGURE 4.
LOCATIONS OF ABANDONED LANDFILLS

A - ABANDONED TOWN OF UNION LANDFILLS
B - ABANDONED VILLAGE OF ENDICOTT LANDFILL

A survey of the immediate area was conducted to determine possible sources of contamination. Local industries and old landfill sites were located. Figure 4 shows the location of three previously used landfills adjacent to the golf course property. The two small northern sites were municipal landfills operated by the Town of Union and the larger southern site was a municipal landfill operated by the Village of Endicott. These sites have not been operated since the late 1970's.

Industries located in the vicinity of the golf course include Hancor, Inc., IBM, and Endicott-Johnson. Due to their remoteness to the site, IBM and Endicott-Johnson were considered as unlikely sources. According to local officials the chemicals used by Hancor, Inc. were not compatible with the contaminants found in the Ranney well. In addition the onsite Hancor well was sampled and analyzed for EPA 601 priority pollutants. No contamination was detected. However, due to the characteristics of the Hancor well, lack of contamination in the water sample does not in itself preclude the possibility that contamination may be present on the site.

The literature search and sampling of existing wells resulted in no conclusive source or sources. Therefore, it was necessary to limit the initial drilling phase to the immediate area surrounding the Ranney well.

III. Drilling, Installation, and Sampling of Monitoring Wells

Drilling was begun at the En-Joie Golf Course on the week of June 20, 1983 under the supervision of DEC engineering geologists. The drilling contract was awarded by the Village of Endicott to Catoh Environmental Services of Savannah, NY. A total of ten borings were completed by the contractor, with nine wells being installed. One boring was abandoned and backfilled, as insufficient water was encountered. Following contract termination three subsequent wells were drilled and installed using the Division of Water's auger drilling rig, and DEC personnel.

All holes were drilled by the hollow stem auger method. Five foot lengths of auger were advanced to the desired depth, then the well was installed through the inside of the augers. The augers were then withdrawn, leaving the well in place. Soil sampling was conducted by the contractor at 5 or 10 foot intervals during the drilling at the discretion of the DEC geologists. A 2 foot split spoon was driven ahead of the lead auger using a 140 pound hammer. Samples recovered from the spoon were field logged, and placed in jars and retained for laboratory grain size analysis.

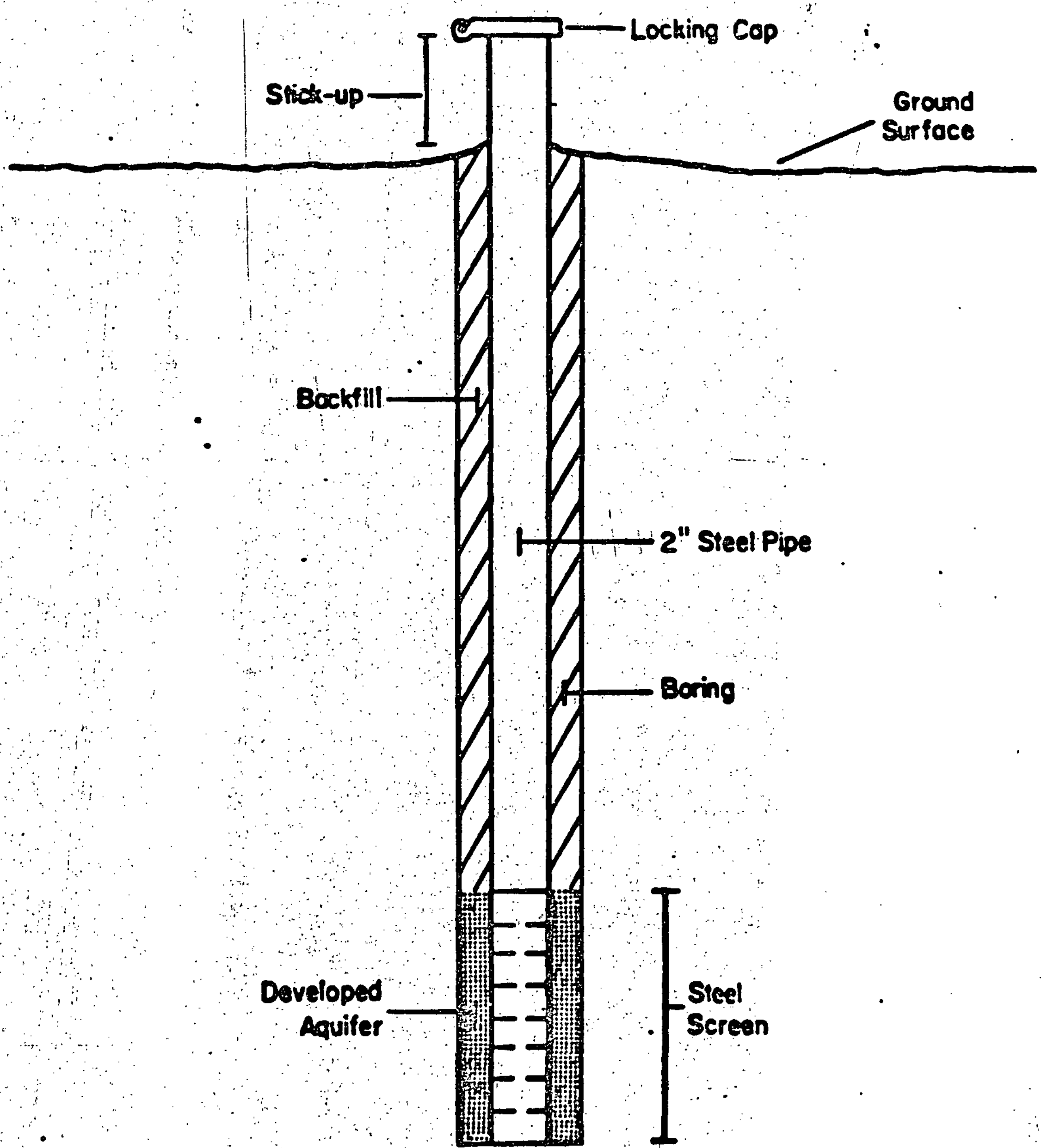
The wells were constructed of 2 inch steel pipe, with low-carbon steel 5 foot screens. Screens with 10 slot (0.010") or 20 slot (0.020") openings were used depending on the material encountered. The tops of the casings extended 2 to 3 feet above ground surface, and were fitted with locking caps. The holes were backfilled using the cuttings brought up during drilling. Figure 5 illustrates the monitoring well construction.

Once each well was completed, it was developed to remove the finer material from around the screen, and thus facilitate the movement of water into the well. Most of the wells were developed using a compressed air method. In this method an air line from a compressor is lowered into the well and the air pumped into the well forces water and fine material to the surface, thus cleaning the screen. Development continues until the water coming to the surface is clear. One well was developed by continuous pumping using a large peristaltic pump. Pumping was continued until the water cleared.

The procedure outlined below for obtaining water samples from the monitoring wells was followed during every round of sampling. A water level reading was taken in the well and compared to the total well depth, to determine the volume of standing water in the well. Three volumes of water were then removed from the well prior to sampling. The evacuation was performed by using a peristaltic pump, if the water level was within suction limits, or by hand bailing with a steel bailer if not within the capacity of the pump.

Water samples were obtained using a modified Kemmerer sampler. The sampler permitted water to be obtained from whatever depth was desired in the well, and provided a minimum of agitation or aeration of the samples. Three 40 ml. glass vials with teflon seals were filled from each well. The samples were stored in an ice chest until delivered to the Department of Health laboratory in Albany. Each monitoring well, with the exception of the final three, was sampled twice, some weeks apart. Complete sample results are included in Appendix D.

FIGURE #5. MONITORING WELL CONSTRUCTION



The drilling of the monitoring wells was carried out in phases. Generally, three wells were installed and sampled. After the results of those samples were received, three more wells were spotted and installed. This was done in an attempt to provide better information for siting each successive phase of the drilling.

The actual siting of the wells was dependent on various factors including:

a) The orientation and depth of the contaminated laterals in the Ranney Well.
b) The subsurface geology as determined from existing wells and borings.
c) Accessibility of drilling sites on the golf course.
d) Possible likely directions of contaminant sources.

Figure 3 shows the location of the Ranney well, the monitoring wells, and existing wells and borings in the study area. The first group of 3 wells, B1-B3, were placed in an approximate arc 600-700 ft. to the north and northwest of the Ranney well. At the time it was hoped that a test well drilled by the Ranney Company in 1948, located 500 ft. due west of the Ranney well could be cleaned, redeveloped, and used as a sampling point. This subsequently proved to be unfeasible. Examination of the physical and chemical properties of the contaminants indicated that they would tend to move in a groundwater system with a slightly downward flow component (a fuller discussion of contaminant chemistry is included in a later section), thus it was felt that the monitoring wells would intercept the contamination at a somewhat higher level than at the laterals of the Ranney well. The wells were drilled and installed such that the bottoms of the screens were approximately 20 ft. above the uppermost tier of laterals in the Ranney well.

Wells B-1, B-2, and B-3 were sampled initially on June 27, 1983. B-1 showed minor amounts (10 ppb) of several organic compounds. B-2 showed 100 ppb trichloroethylene and 15 ppb trans-1,2-dichloroethene. B-3 had 110 ppb vinyl chloride, 84 ppb trans-1,2-dichloroethene and 33 ppb chloroethane. Since B-3, furthest to the northwest had a high concentration of vinyl chloride, the next phase of drilling was conducted further to the west and north.

Attention was given to possible sources of the contamination to the west and north. Well B-4 was spotted west-north-west of B-3, near Nanticoke Creek, in an attempt to determine if any contamination was being drawn under the creek from the Endicott landfill. B-5 was located at the northwest corner of the golf course in the direction of an old Town of Union landfill. B-6 was located well to the north of B-3 to determine if any contamination was moving from that direction.

The screens of wells B-4 and B-5 were set at a depth of 50 feet. Well B-6 encountered gray clay at 41 ft. Well B-6 was drilled 10 ft. deeper with no change in material. Existing borings to the north and east indicated that the clay layer was quite thick, and the decision was made to set the screen on top of the clay. Thus, any contamination migrating on the surface of the impermeable clay could be detected.

Wells B-4 and B-5 were sampled on July 20, 1983. B-6 was not sampled at that time because development of the well was not yet completed. Wells B-1 through B-3 were resampled. B-4 and B-5 had no parameters above detectable limits. Results from B-2 and B-3 were fairly consistent with the previous sampling, although the vinyl chloride concentration in B-3 was lower (99 ppb). Well B-1 showed no contamination in the second sampling.

Since no contamination was evident in B-4 and B-5, the next set of wells was sited closer to B-3. Hole B-7 was drilled north of B-2, to 50 ft. Gray clay was encountered at 21 ft., with insufficient water to place a well. The hole was abandoned and backfilled. Well B-8 was drilled north of B-3 to a total depth of 40 ft. Gray clay was encountered at 28 ft. and the screen was set on top of the clay. A water sample was obtained through the augers when water was first encountered, in addition to the sample taken after development.

B-9 was drilled at the southwest corner of the golf course to 50 ft. B-10 was drilled due west of B-8 to 52 ft. Gray clay was encountered at 51 ft. Sampling was conducted on August 18, 1983. Wells B-4 and B-5 were resampled in addition to B-6,B-8,B-9, and B-10 and a well located to the northwest of the golf course, at a gas station on Rt. 17-C was also sampled. Results from all wells were negative, with the exception of 3 ppb chloroethane in B-9. Wells B-6,8,9, and 10 were resampled on September 23, 1983. B-9 showed 2 ppb chloroethane, while all other results were negative.

In addition to the analyses conducted for volatile halogenated organics, samples were taken on July 20, 1983 for priority pollutant metals from wells B-1 through B-5. High concentrations of these parameters could indicate the presence of landfill leachate. Laboratory results for these analyses are presented in Appendix E. A discussion of these results is presented in subsequent sections.

Drilling rerumed during the week of October 24, 1983 using the Division of Water's recently acquired auger rig. Wells B-5,B-6,B-8,B-9, and B-10 were pulled and the materials were reused for the subsequent wells. These wells were removed since sample results had been negative, and they exhibited little or no response to an aquifer pumping test conducted in September (to be discussed in a later section).

Well B-11 was drilled adjacent to the site of B-9, with the screen being set 15 ft. deeper, at 65 ft. This was done to explore the possibility of contamination migrating under Nanticoke Creek at deeper levels than were previously considered. B-12 was drilled about 330 ft. west of B-3 to a depth of 65 ft. B-13 was drilled 250 ft. north of B-3 to a depth of 65 ft. Samples from these three wells were obtained on October 27, 1983. Results of the analyses were not received until December 8, 1983 due to laboratory equipment breakdown. B-12 showed high concentrations of several organic compound, notably chloroethane (280 ppb) and vinyl chloride (66 ppb). B-13 contained 50 ppb chloroethane, 17 ppb vinyl chloride, and 64 ppb trans 1-2 dichloroethylene. B-11 showed 5 ppb chloroethane.

IV. Site Geology

The study area is located in the western portion of the Village of Endicott, NY. It consists basically of the En-Joie Golf course, and is bounded on the east by Roundtop Hill, the south by the Susuqhanna River, the west by Nanticoke Ck., and the north by Main St. (Rt. 17C). It was within the confines of this area that the test drilling was conducted, however, sampling was conducted in, and attention was given to areas to the north and west, in the direction of potential sources of contamination.

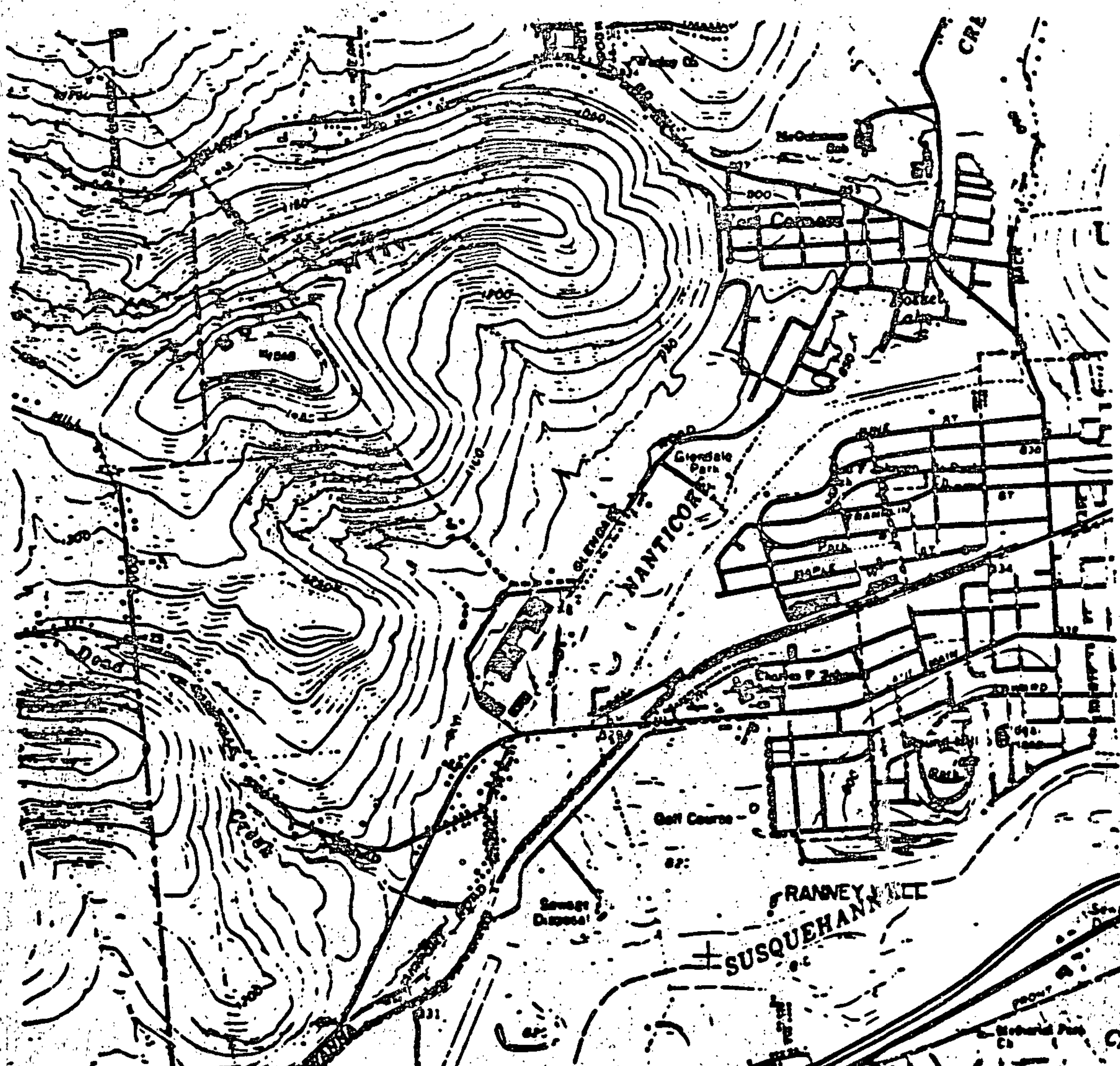
The terrain in the Endicott area has been described at a maturely dissected plateau, characterized by the absence of flat uplands and the development of flood plains in the major stream valleys (Coates, 1963). The Susquehanna River provides the major drainage in the area, flowing westerly along the southern boundary of the study area. Nanticoke Creek, flowing south, joins the Susquehanna just west of the En-Joie Golf Course (Figure 6).

The bedrock underlying the region consists of Upper Devonian shales and siltstones of marine origin. These rocks dip to the southwest at about 11 ft/mile. Locally, at the site, these rocks are buried by 100 ft. or more of unconsolidated sediments, with the exception of a bedrock knob, Roundtop Hill, just east of the golf course. The bedrock is not an important source of ground water, except for individual households remote from public supply. The rocks are of low permeability, and bedding planes and joint systems provide the limited passages for ground water movement.

Pleistocene glaciation had a pronounced effect on the region. Ice, 3,000 ft. thick covered the area, depositing a blanket of poorly sorted till. The till is readily evident on the uplands and valley sides, while in the valleys, it has been buried by subsequent deposits, or eroded away by glacial meltwater. In the waning period of glaciation, the ice apparently wasted away in stages. This continuing process yielded tremendous amounts of valley-fill deposits, which were dropped in place from the wasting ice, washed down valley by meltwater streams, or deposited in localized lakes. The total thickness of these deposits is in the order of 100 to 200 ft. in the study area.

Ice contact features developed along the ice margin. Kame terraces formed between the ice and the valley walls, consisting mainly of sand and gravel. Later, silt and clay was deposited in lakes near the ice margin, and meltwater rushing into the lakes eventually capped the fine sediment with sand and gravel outwash. In places, large blocks of ice detached from the main body, melted in place, leaving depressions known as kettle holes, many of which were subsequently filled with fine-grained flood plain deposits. These kettle hole deposits may overly outwash or ice contact sand and gravel deposits.

The bedrock knob known as Roundtop is evidence of older glacial advance in this area (Coates, 1963,1981). The pre-glacial river originally flowed north of Roundtop. Ice blocking this channel forced water to flow over a bedrock spur to the south, cutting a new channel, and isolating Roundtop as an umlaufberg. There are several such features in the Susquehanna drainage system. The valleys on both sides of Roundtop were widened and smoothed by subsequent ice sheet(s).



FIGURE#6. PORTION OF U.S.G.S. ENDICOTT QUADRANGLE, SHOWING LOCATION OF GOLF COURSE STUDY AREA

The golf course area is located between the present Susquehanna River channel on the south, and the old channel to the north, which lies approximately under the Main St.-railroad bed area. The present river channel is underlain by 100 ft. or more of coarse outwash sand and gravel deposits, as can be seen in the logs of test wells drilled by the Ranney Corporation in the 1940's (Ranney Corp., 1947). These wells were located in the vicinity of the present Ranney well and in the bed of the river immediately to the south.

Figure 3 shows the location of existing wells and borings. Logs compiled by Randall (1972) show that the abandoned channel to the north is as much as 200 ft. deep. This channel was filled in with fine-grained deposits of clay and fine sand. Well 49-31 (Randall, 1972), encountered bedrock at 202 ft. and contained 172 ft. of blue clay overlying a thin layer of silty fine sand. These sediments are consistent with a lacustrine origin, and the inference that can be drawn is that water ponded in the abandoned channel, dammed by the great thickness of stratified drift filling the present valley. This lake became filled with a considerable thickness of fine grained sediment, to such shallow depth that outwash could prograde across the remaining water as deltas (Randall, written communication, 1984).

The golf course area is a transitional area, between thick lacustrine clay in the north, and coarse outwash deposits in the south. It was hoped that the test well drilling would further define where the clay pinches out or interfingers with the outwash sand and gravel, as this could be a controlling area for ground water movement. In addition, if contamination was migrating in the ground water on the surface of the clay, it would disperse into the sand and gravel, moving downward toward the Ranney well in this discontinuous zone.

The first group of three wells, B1-B3, penetrated up to 70 ft. of sand and gravel, with no significant clay encountered. B-4 penetrated 28 ft. of silt and clay before hitting gray sand and gravel. A similar sequence was encountered in B-9 and B-11 to the south, and B-12 to the southeast. This sequence is consistent with that encountered in borings in a kettle hole to the east of the study area in the Jr. High School area (Randall 1972; Holecek, et al, 1982). This silt and clay may represent floodplain deposits filling a large kettle hole rather than the more extensive lacustrine clay.

B-6 in the north-central area penetrated gray clay at 41 ft. B-7, drilled to 50 ft., penetrated 30 ft. of gray clay before drilling was halted, and the hole was abandoned. B-8 encountered clay at 28 ft., and B-10 at 51 ft. B-5, drilled to 50 ft. in the northwest corner of the golf course did not encounter gray clay. The last hole, B-13, between B-3 and B-8 was drilled to 65 ft. in gravel and brown sand.

The logs of the test wells are in good agreement with the surficial geological map of the area by Holecek, et al, (1982). The contact between the lacustrine clay and the sand and gravel, and the location of the kettle hole can be further defined from the test drilling. Figure 7 illustrates the surficial geology of the study area. Figures 8 and 9 are geologic cross-sections through the area, constructed from logs of the test wells and pre-existing wells.

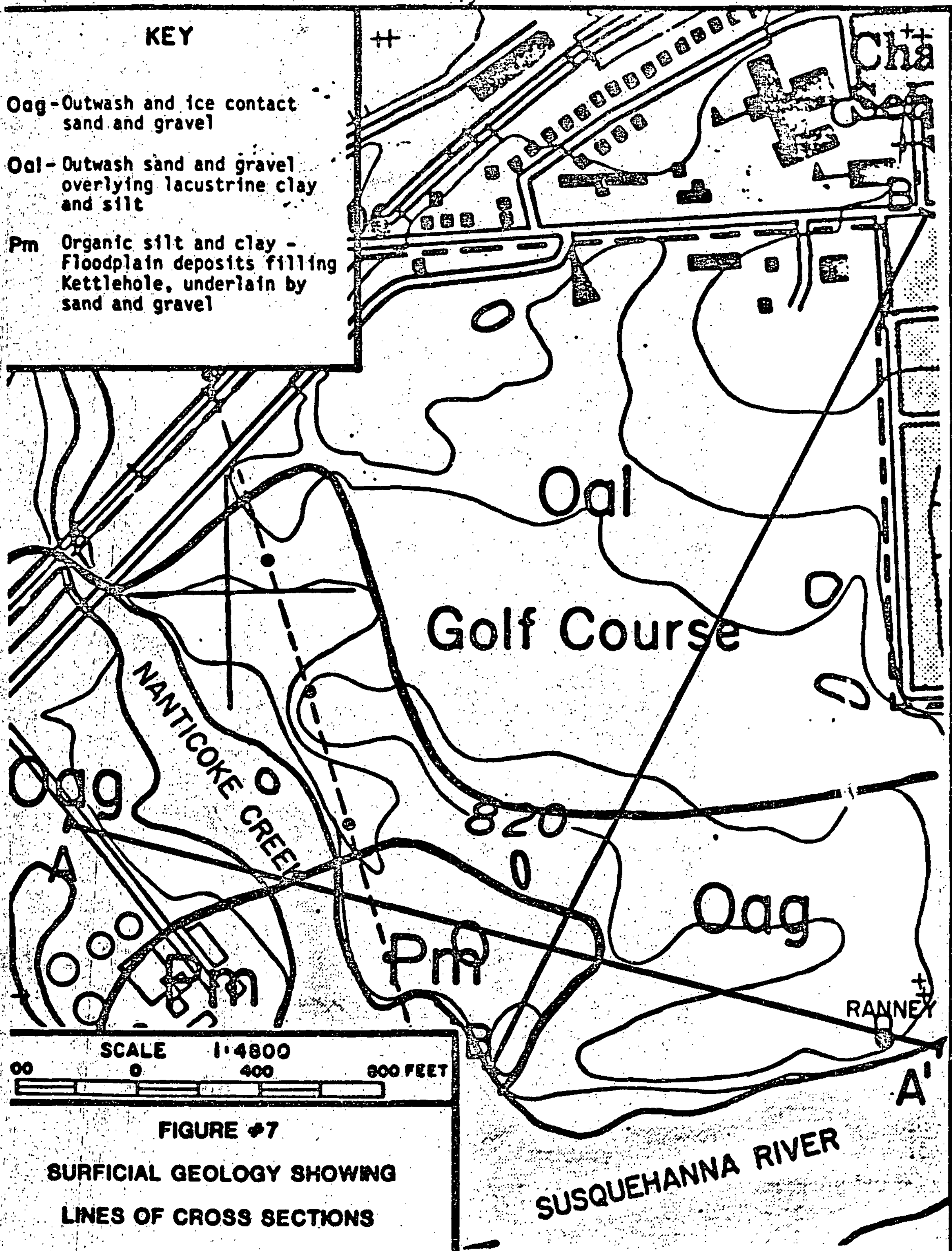
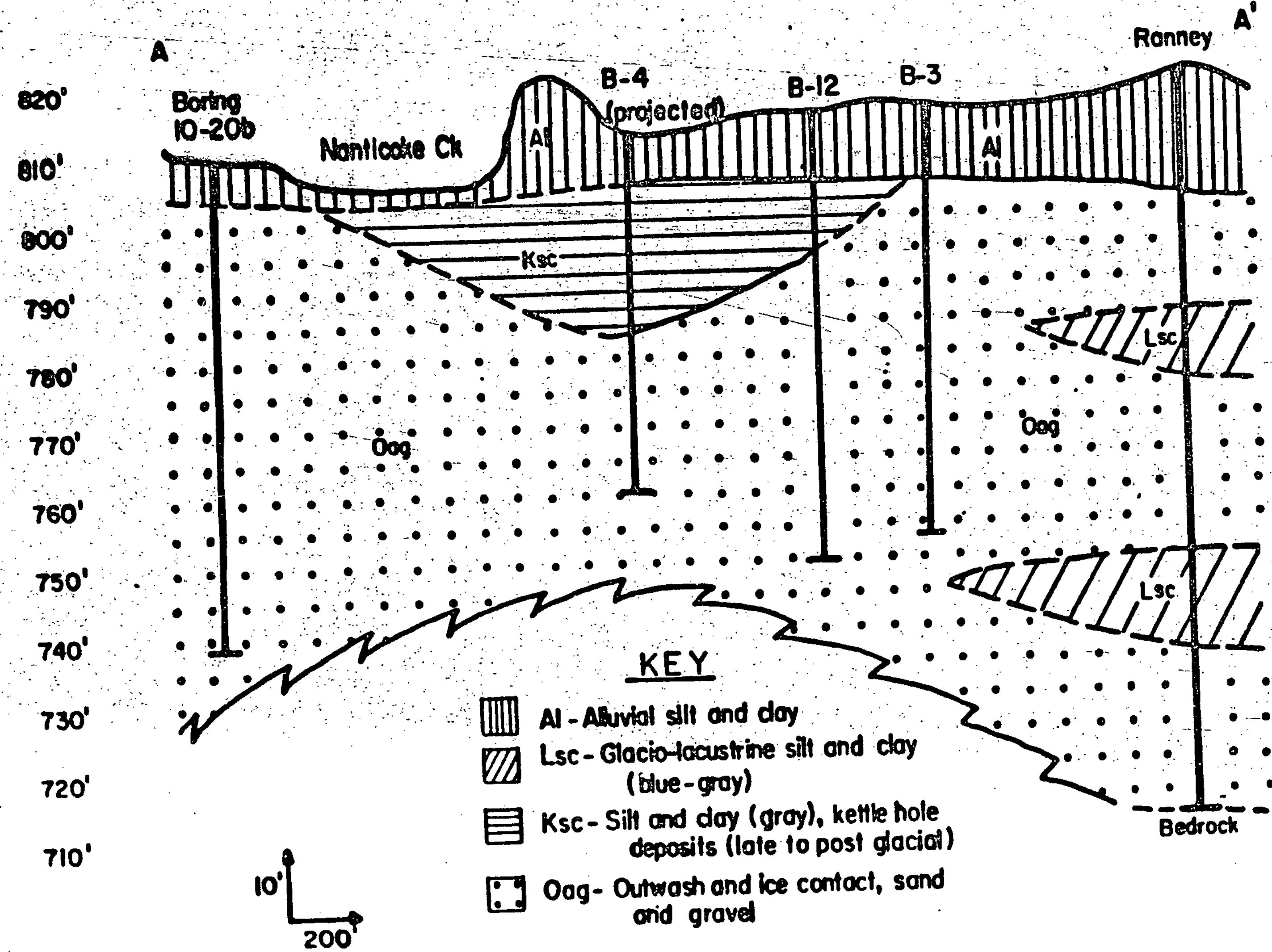


FIGURE #7

SURFICIAL GEOLOGY SHOWING

LINES OF CROSS SECTIONS



FIGURE#8. GEOLOGIC CROSS SECTION ALONG LINE A-A'

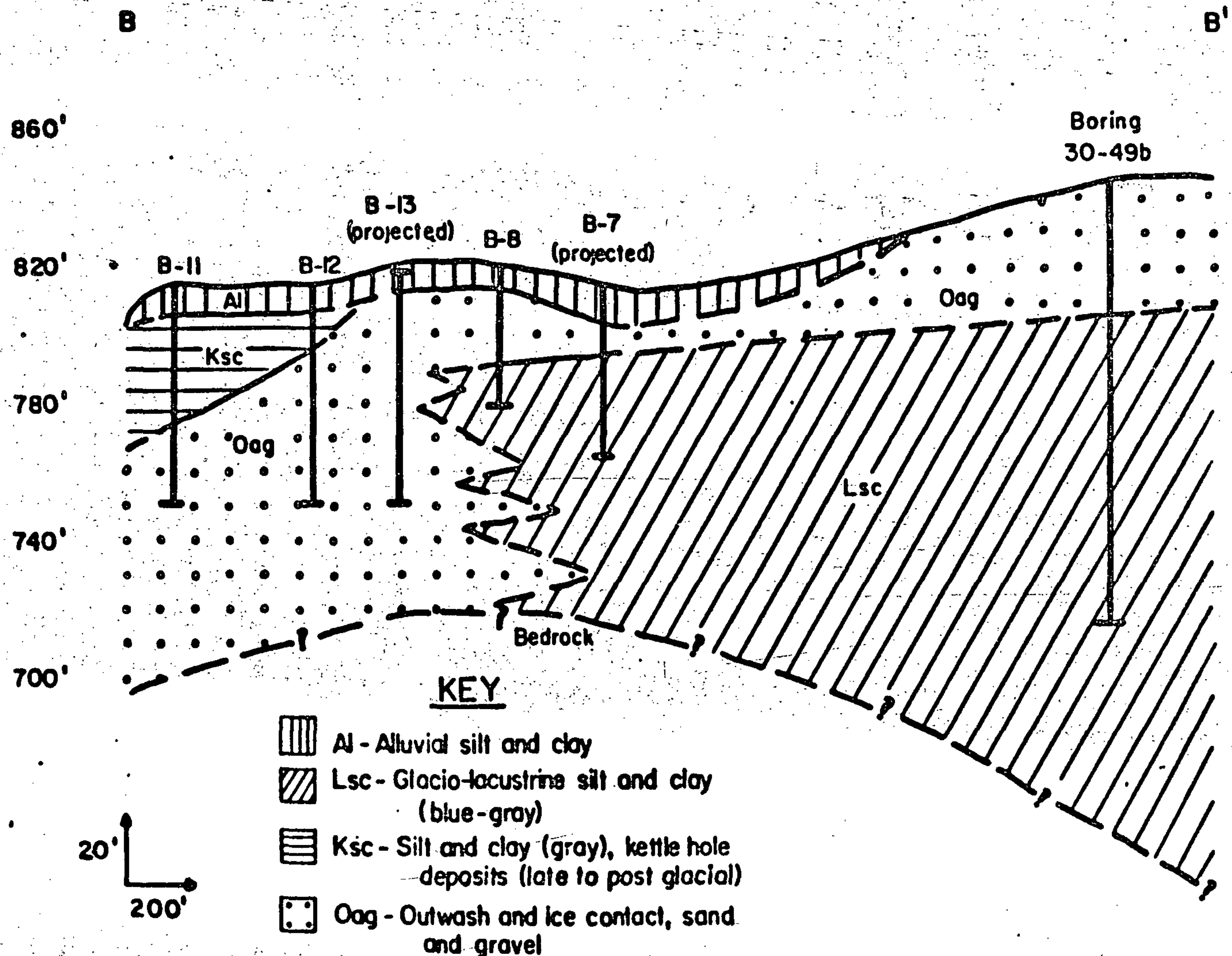


FIGURE 9. GEOLOGIC CROSS SECTION ALONG LINE B-B'

V. Aquifer Pumping Test

An aquifer pumping test was conducted at the study area during the week of September 19, 1983. The test was conducted in order to define the aquifer parameters of transmissivity (T), and coefficient of storage (S). Transmissivity is defined as "the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient", while coefficient of storage is "the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head" (Lohman, et al, 1972). In addition, the test would provide insight into the area of influence of the Ranney collector well, and the percentage of water entering the well that is derived from induced infiltration of Susquehanna River water.

The Ranney well was used as the pumping well, and was pumped at the rate of 3700 gallons per minute (gpm). Normal pumping test procedure calls for a period of non-pumping, sufficient to allow the water table to recover to static level prior to the start of the test. Following the pumping test, water level measurements are taken during a recovery period. Since the supply of water from the Ranney well is critical to the Endicott Water System, it was not possible to cease pumping for more than 24 hours. Thus, the Ranney well was shut down for 24 hours and recovery was monitored first, followed by a resumption of pumping and the monitoring of drawdown.

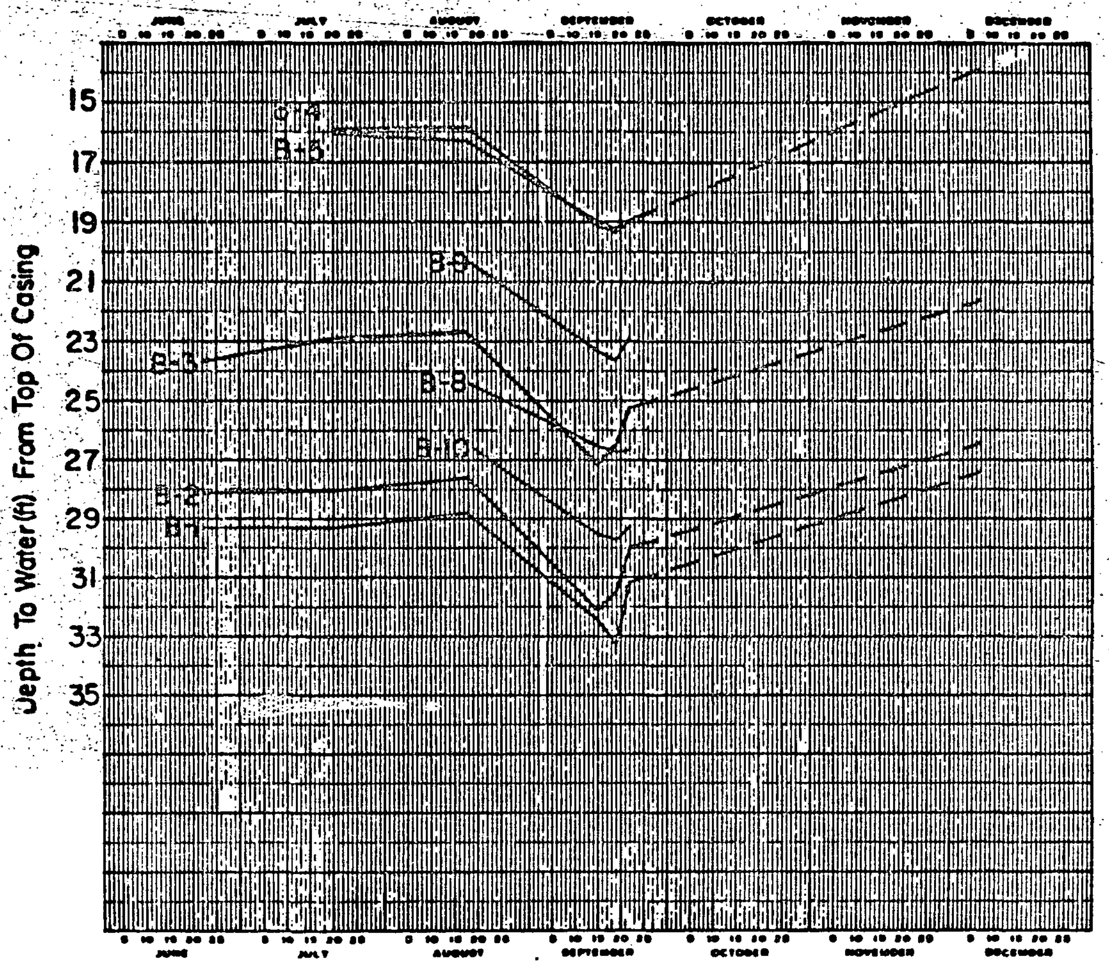
Automatic water level recorders, provided by the U.S. Geological Survey were installed on the Kelley well and B-1. USGS personnel assisted in conducting the test. Water levels in wells B-2 through B-10 were measured with either chalked tapes or electric meters. In addition, river stage was monitored at a recorder in Vestal, and at a staff gauge in the river opposite the Ranney well.

Water level measurements were taken at different times during the summer, and several measurements were taken in the days prior to the test in order to define any existing trends. Figure 10 illustrates the trends of water levels in the wells from June 22, through December 7, 1983. All tapes and meters used in the test were calibrated to a standard steel tape, and correction factors for each were determined.

Manual readings were taken at very short intervals (30 to 60 seconds) at most wells during the first 20 minutes of both the recovery and drawdown tests, with intervals increasing gradually to 1 to 2 hours toward the latter part of each test. One person monitored both B-4 and B-9, while another monitored both B-5 and B-6. These wells are furthest from the Ranney well, and would be expected to respond slowly.

Figures 11 and 12 represent hydrographs of the wells that responded to the test sufficiently to provide meaningful data. Wells B-4 through B-8, and B-10 showed no detectable response to the test. B-9 responded very slightly during the recovery test but reacted erratically to the drawdown phase. A major rainfall event occurred during the afternoon and evening of the drawdown test, and its effects can be seen in the hydrographs of the river and the Ranney and Kelley wells (Figure 11).

FIGURE# 10.



Trends of Water Levels in Endicott Test Wells - June to December, 1983

FIGURE#11. HYDROGRAPHS OF SUSQUEHANNA RIVER, KELLEY AND RANNEY WELLS DURING RECOVERY AND PUMPING TEST

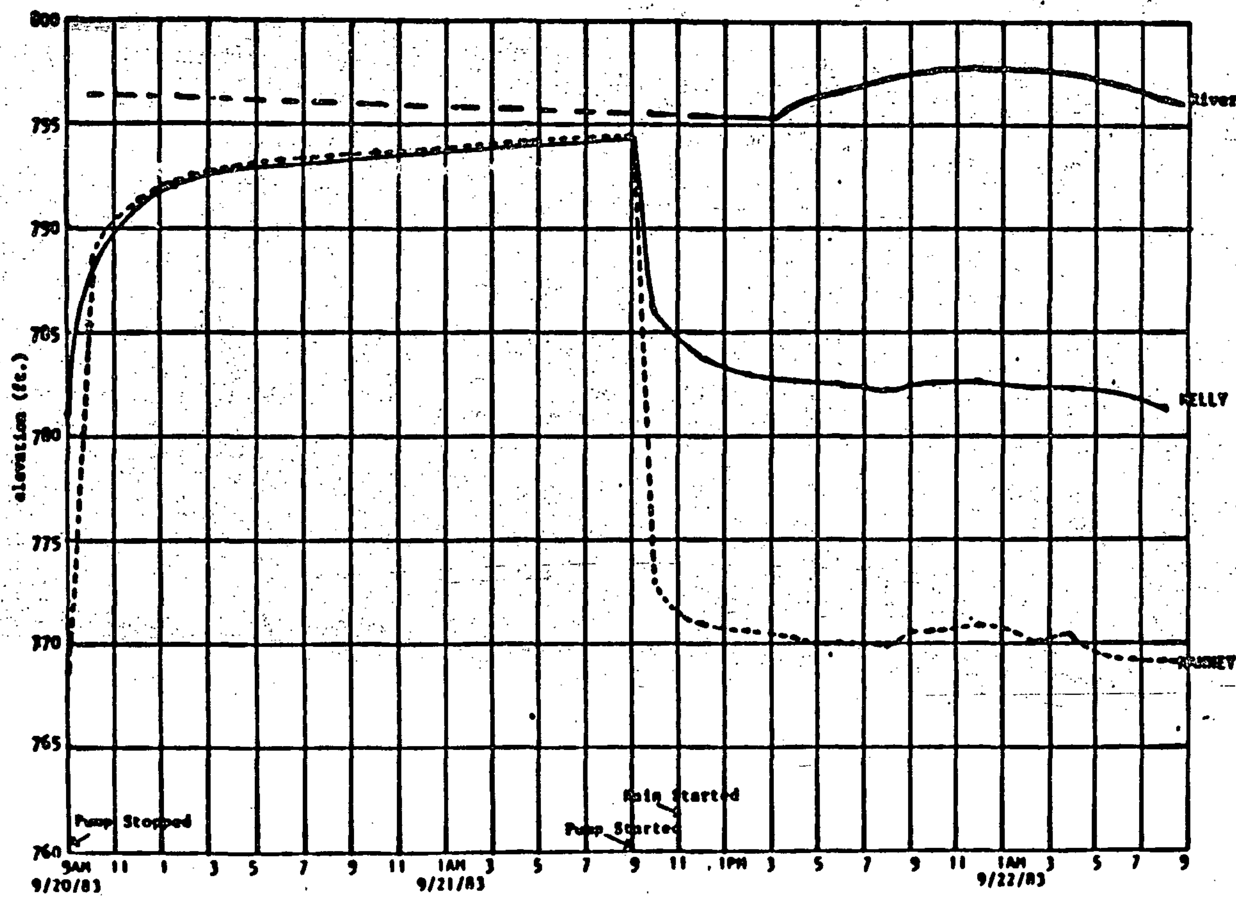
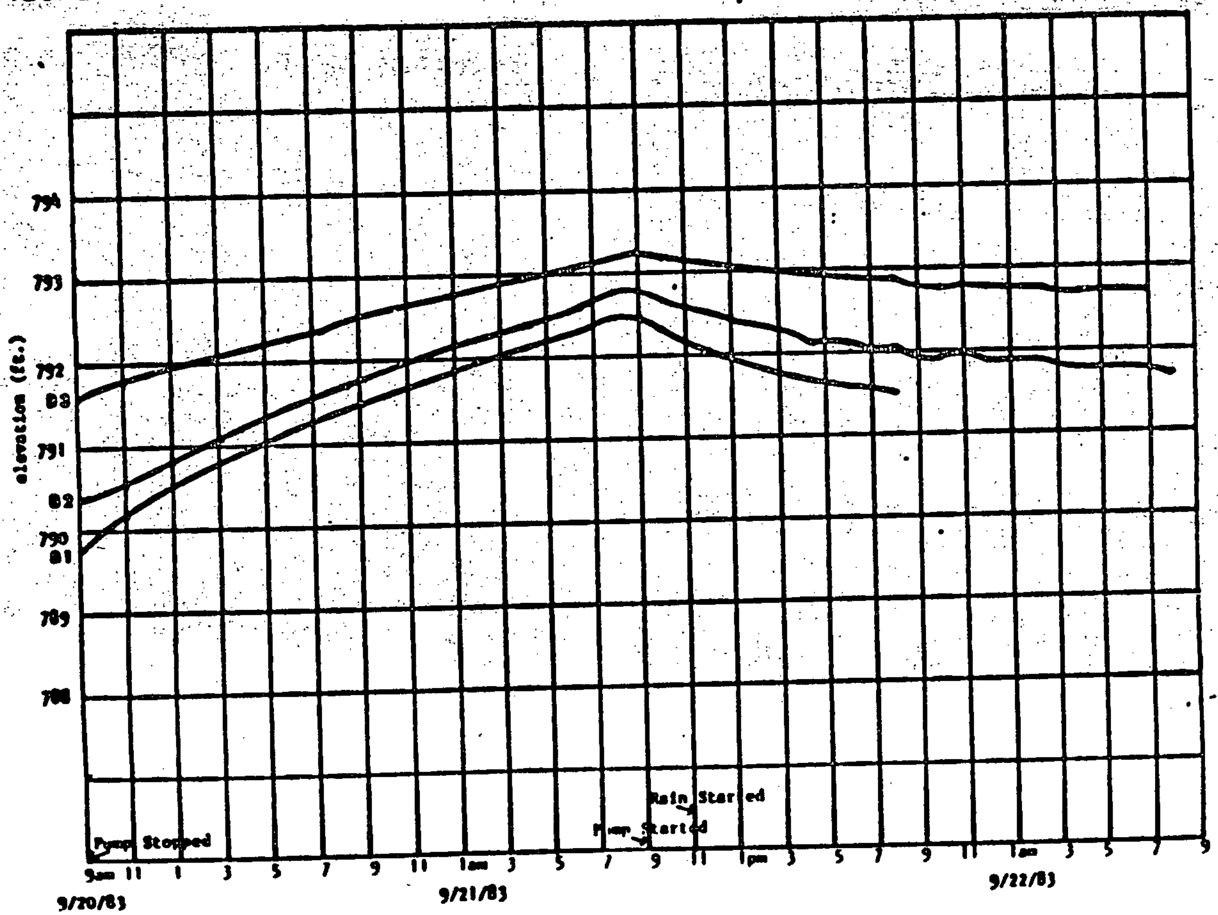


FIGURE #12. HYDROGRAPHS OF WELLS B-1, B-2, B-3 DURING RECOVERY AND PUMPING TEST



The Ranney, Kelley, and wells B-1 through B-3 responded well to both tests. Unfortunately, the recorder malfunctioned on B-1 part way through the drawdown phase, and the problem was not detected until the end of the test. Table 2 summarizes the recovery and drawdown data for responding wells.

Table 2: Aquifer Test Recovery and Drawdown Summary

Well	Recovery Time	Recovery(ft)	Pumping Time	Drawdown(ft)
Ranney	24 hrs.	25.66	27 hrs.	24.60
Kelley	"	13.30	" "	12.60
B-1	"	2.72	" "	1.46
B-2	"	2.41	" "	1.15
B-3	"	1.62	26 hrs.	0.57
B-9	"	0.63	27 hrs.	0.06

Data from the recovery portion of aquifer tests often is more reliable for calculating aquifer parameters than the drawdown data, as recovery is not subject to any fluctuations in pump discharge. Unfortunately, the time limitations imposed on the Endicott test by village water demand prevented accurate calculation of parameters from the recovery data for two basic reasons. First, pumping was not stopped long enough for a true static water level to be attained. Secondly, the necessity of monitoring recovery prior to drawdown does not permit the extrapolation of the drawdown curve beneath the recovery curve, which is necessary in order to calculate true recovery and residual drawdown. Sufficient drawdown data was obtained however, to analyze the aquifer by various methods, thus providing a good check on the results. A general discussion of these methods follows.

Drawdown data was analyzed first by the Jacob non-equilibrium method, as outlined in Johnson Division, U.O.P. Inc. (1982). Drawdown, in feet, is plotted on an arithmetic scale, and time since pumping began, in minutes, is plotted on a logarithmic scale on semilog graph paper. Under ideal conditions, all of the data points except for the first few minutes of the test should approximate a straight line. Transmissivity and coefficient of storage can be calculated from this plot using the following formula:

$$(1) \quad T = \frac{264Q}{\Delta s}$$

where: T = transmissivity in gallons per day per foot (gpd/ft.)
Q = pumping rate in gallons per minute (gpm)
Δs = slope of the graph expressed as the change in drawdown across one complete log cycle.

(2) $$S = \frac{0.3Tt_0}{r^2}$$

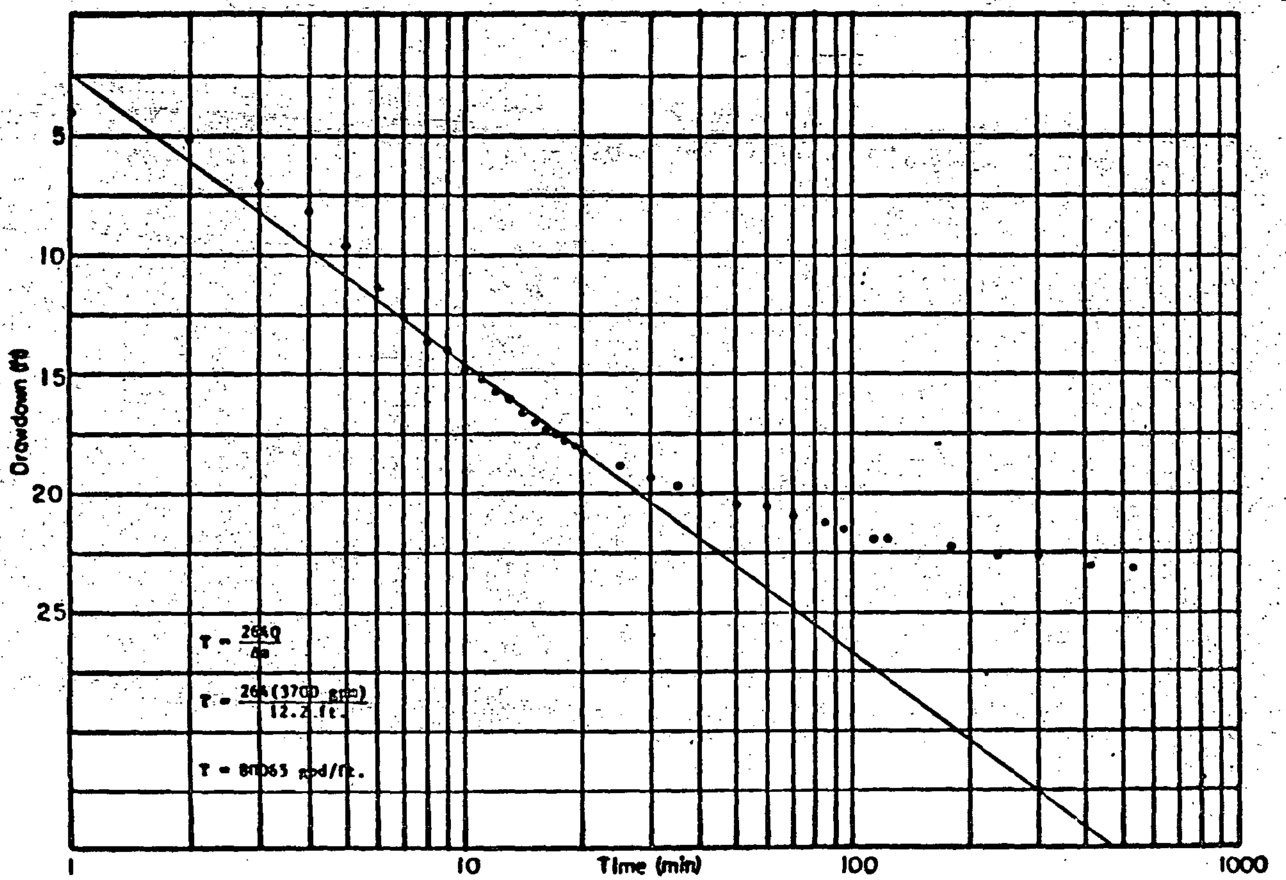
where: S = coefficient of storage (dimensionless)
T = transmissivity (gpd/ft)
t_0 = intercept of straight line zero drawdown, in days
r = distance in ft., from pumped well to observation well.

A well discharging from an aquifer adjacent to, and hydraulically connected with a source of recharge, such as the Susquehanna River, ultimately derives much of its water from induced infiltration from this source. The existence of such a hydraulic connection between the aquifer and the river had already been established by the Ranney Corp. in a test conducted in 1947 (Ranney Corp., 1948).

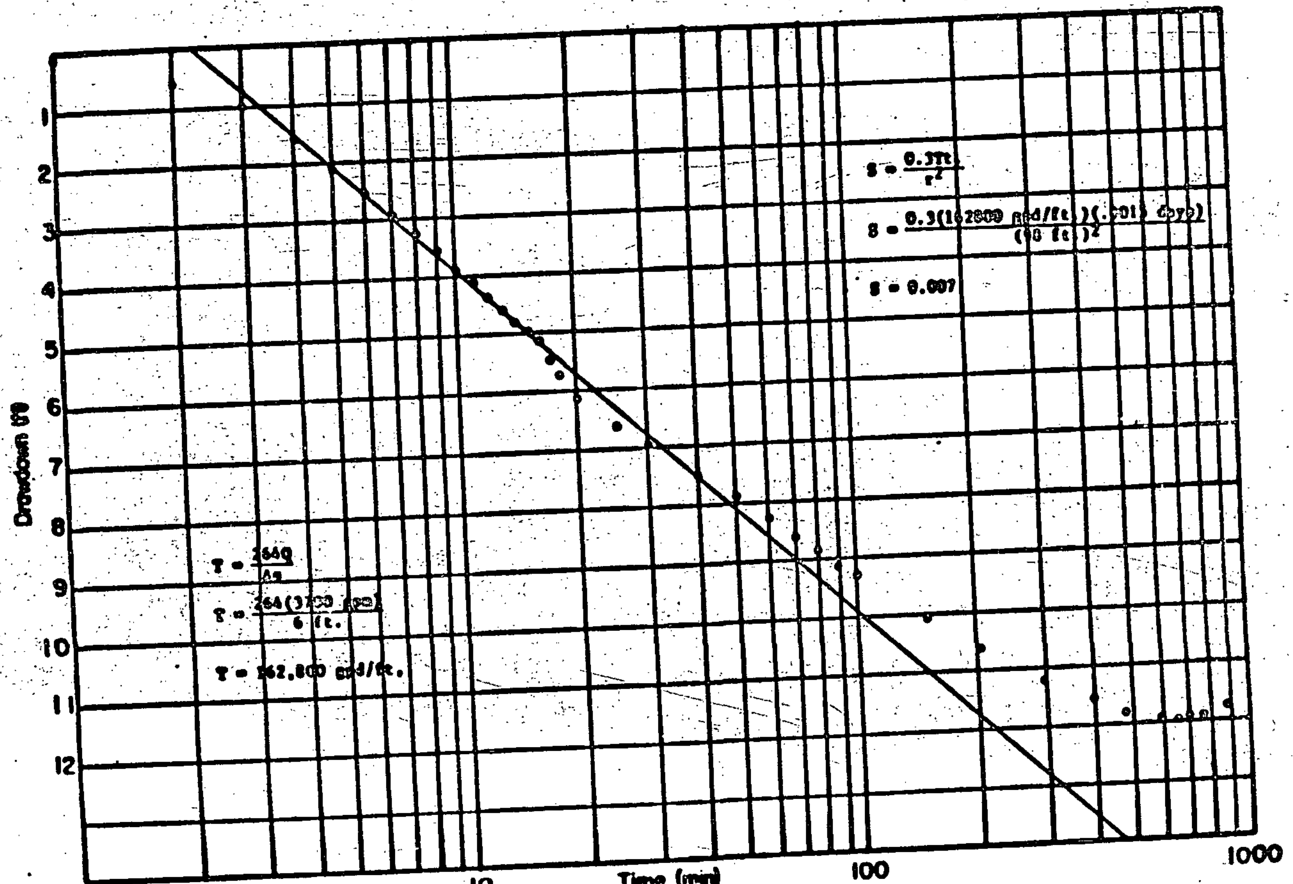
As pumping continues, drawdown increases, and the cone of drawdown around the pumped well expands until it intersects enough recharge to sustain its yield. At this point, the rate of drawdown slows. This is reflected in the time-drawdown plots for the Ranney and Kelley wells by a flattening of the slope of the curve. This portion of the curve cannot be used in computing transmissivity, as the resulting values reflect infiltration of river water. The portion of the curve prior to the flattening of the slope must be used, as this represents the actual drawdown of ground water in the aquifer in response to the pumping rate. Figures 13-17 shows the time-drawdown plots, and the calculations from each. As can be seen from the graph, induced recharge from the river occurred after about 20 minutes at the Ranney well.

Transmissivities calculated from the Ranney and Kelley well data range from 80,000 to 160,000 gpd/ft., which are reasonable values for sand and gravel aquifers. Examination of the graphs from B-1,B-2, and B-3 shows no flattening of the curves from recharge effect. Transmissivities calculated from the slopes of these plots yield anomalously high values. The problem lies in the fact that the "Q" value, or pumpage rate of 3700 gpm is too high for these wells which are considerably further from the recharge source. It must be considered that after about 20 minutes of pumping, the Ranney well is deriving most of its water from infiltration from the river. Thus, it is necessary to determine the approximate contribution of ground water to the Ranney well from the direction away from the recharge source, and adjust the discharge value accordingly.

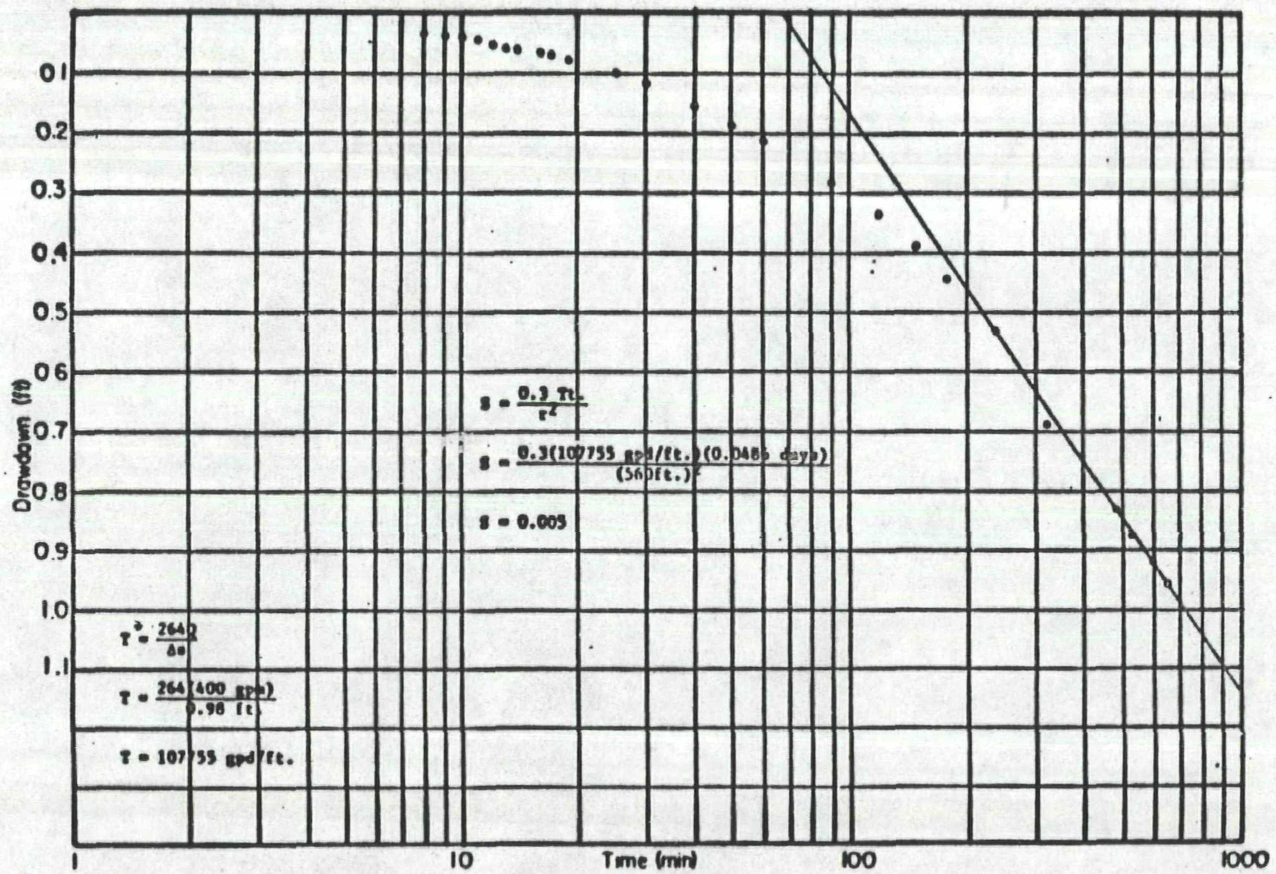
The method discussed below is an attempt to analyze the data from B-1,B-2, and B-3 in a meaningful way that results in values that are consistent with what would be expected from the logs of the wells. Comparison of the logs of the test wells with those of the Ranney and Kelley wells suggests that transmissivities in the vicinity of the three test wells would certainly not be much higher than at the Ranney-Kelley well area, and might, in fact, be lower.



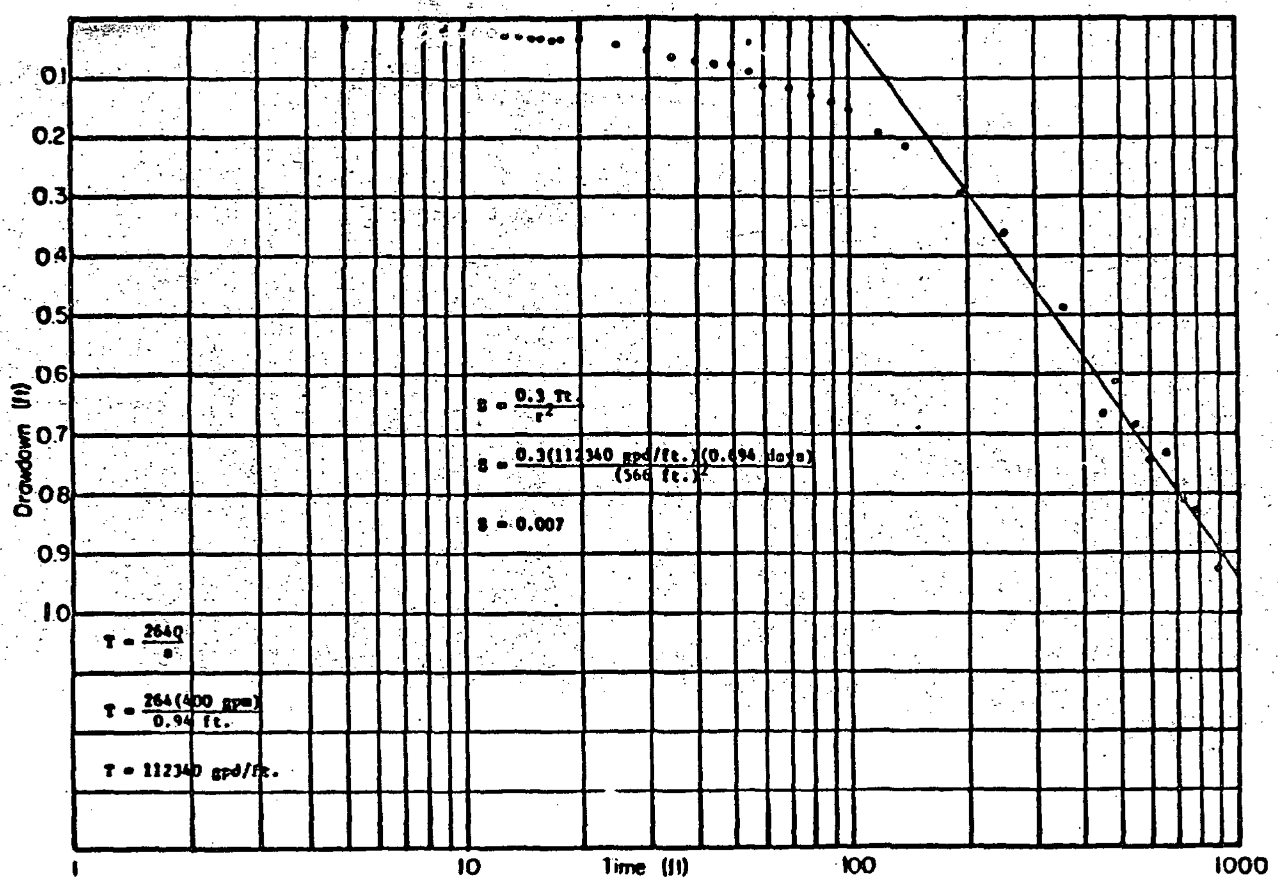
Ranney Well Drawdown vs Time FIGURE#13.



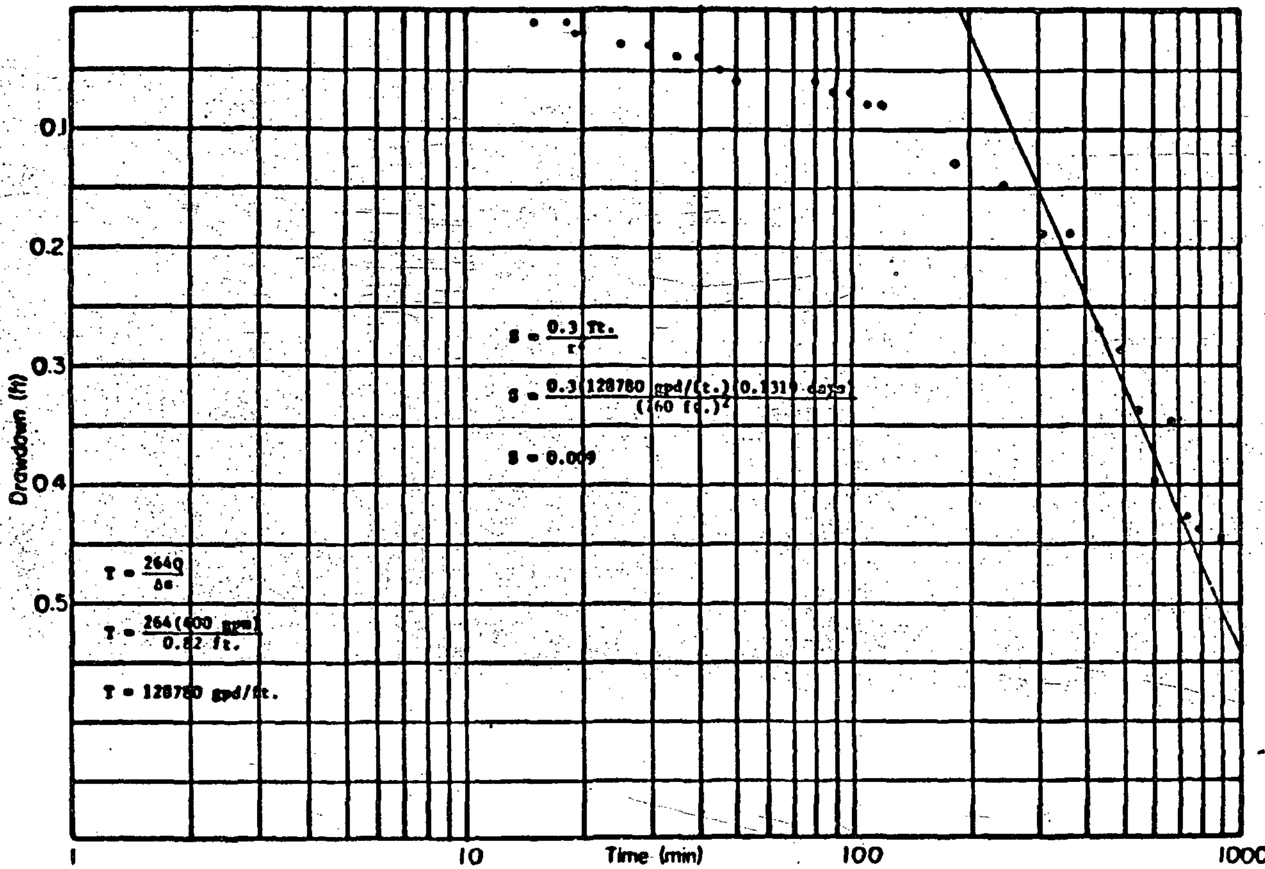
Kelley Well Drawdown vs Time FIGURE #14.



Well B-1 Drawdown vs Time FIGURE#18.



Well B-2 Drawdown vs Time FIGURE#18.



Well B-3 Drawdown vs Time FIGURE#17

Several methods have been devised to determine the percentage of water entering a well that is derived from a recharge source. Some of these methods require an observation well between the pumping well and the recharge source, a condition which could not be met in this study. A method by Glover and Balmer (1954) involves using the aquifer parameters of transmissivity and coefficient of storage, distance to recharge source, and time since pumping began in the following formula:

$$(3) \qquad \frac{x}{\sqrt{4Tt/S}}$$

where: x = distance from well to recharge source in meters
T = transmissivity in meters^2/day
t = time from start of pumping in days
S = coefficient of storage (dimensionless)

Since the above formula requires transmissivity in meters ^{2}/day rather than gallons per day/ft., transmissivity must be calculated according to the formula:

$$(4) \qquad T = \frac{2.3(Q)}{4\pi\Delta s}$$

where: T = transmissivity in meters^2/day
Q = pump discharge in meters^2/day
s = drawdown in meters

Using data from the Ranney well:

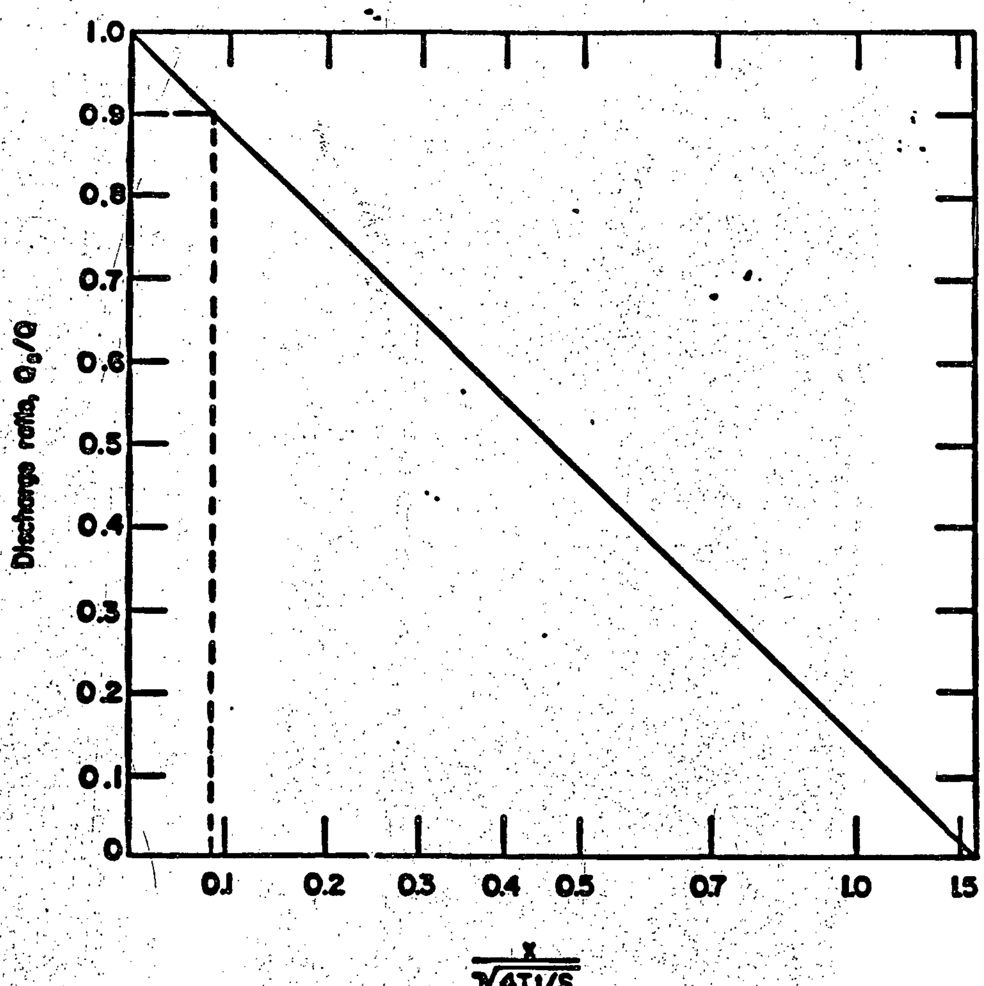
Q = 3700 gpm = 14 m^3/min = 20160 m^3/day
= 12.2 ft. = 3.72 m

$$T = \frac{2.3(20160 \text{ m}^3/\text{day}}{4\pi(3.72 \text{ m})} = 989 \text{ m}^2/\text{day}$$

The values required for Formula (3) are:

x = 50 m
T = 989 m^2/day
t = 0.69 days
S = 0.007

Figure 18 shows the graph of Glover and Balmer (1954), and the solution of Formula (3). The graph yields a percentage of contributions from the stream of 90%. A study at the Endicott South St. well field determined that a well adjacent to the river at that location derived approximately 94% of it's water from the river (Ground Water Associates, Inc., 1978); thus this value appears reasonable.



Q_s = discharge derived from the stream
Q = total well discharge.

$$\frac{x}{\sqrt{\frac{4Tt}{S}}} = \frac{50m}{\sqrt{\frac{4(989m^2/day)(0.69\ days)}{0.007}}} = 0.08$$

FIGURE# 18. GRAPH FOR DETERMINING THE PORTION OF WELL DISCHARGE FURNISHED BY NEARBY STREAM

If 10% of the total recharge to the well is contributed from ground water, then the discharge value must be adjusted from 3700 gpm to about 400 gpm for wells B-1 through B-3. Transmissivities calculated from the time-drawdown plots using a "Q" of 400 gpm yielded values of 107,755 to 128,755 gpm, providing much better agreement.

The possibility exists that the steepening of the time-drawdown curves for B-1, B-2, and B-3 may represent an impermeable boundary becoming effective either earlier than or simultaneous with the recharge effect from the river. Attempts to analyze the early data prior to the steepening of the curves by the Theis method (Johnson Division, U.O.P., Inc., 1982) once again yielded anomalously high transmissivity values (1,000,000 gpd/ft). A longer pump test or another pump test with a pumping well in the vicinity of B-1, B-2, and B-3 would be necessary to accurately determine the transmissivity of the aquifer in the vicinity of the test wells, and to verify the validity of the above method of adjusting the discharge value.

The distance-drawdown method provides a fairly reliable check on the time-drawdown calculations. Plotting drawdown on an arithmetic scale against distance from the pumped well on a logarithmic scale for wells lying on an approximate straight line from the pumping well gives a fairly accurate value for calculating transmissivity. The Kelley well and B-2 lie on a nearly straight line from the Ranney well, and were used for the calculation. In addition, the drawdown values for B-1 and B-3 were plotted as a check on the validity of the method.

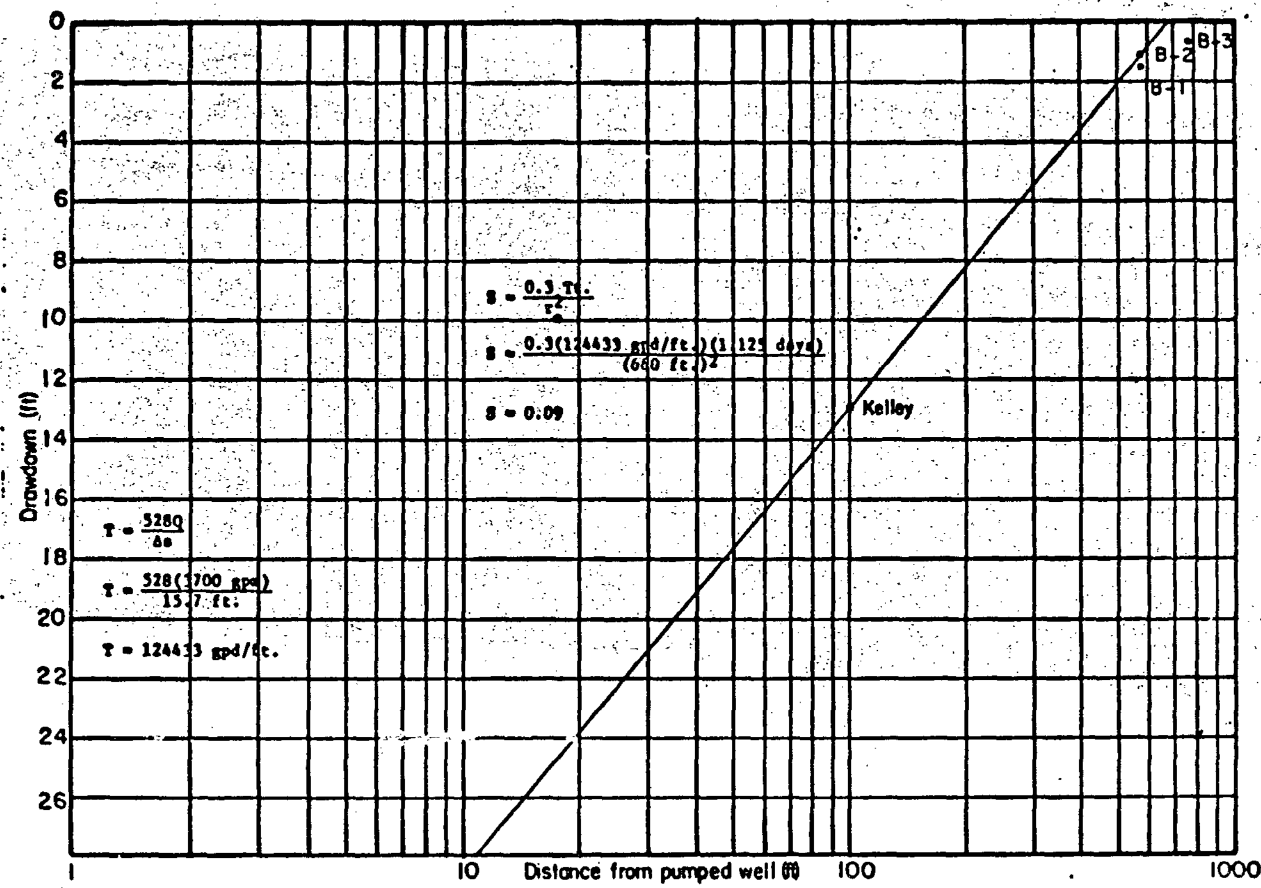
The distance-drawdown plot (Figure 19) yields a straight line, whose slope was used to calculate transmissivity. The formula for this is:

(4) $$T = \frac{528Q}{s}$$ where the units are as defined in equation (1).

The resulting value is 124,433 gpd/ft., and is in good agreement with the time-drawdown data. Extention of the straight line to the zero-drawdown intercept gives the distance from the Ranney well, in this direction, at which no drawdown would occur, at the pumping rate of 3700 gpm. This distance, from the graph is 600 ft., or about 90 ft. northwest of B-2.

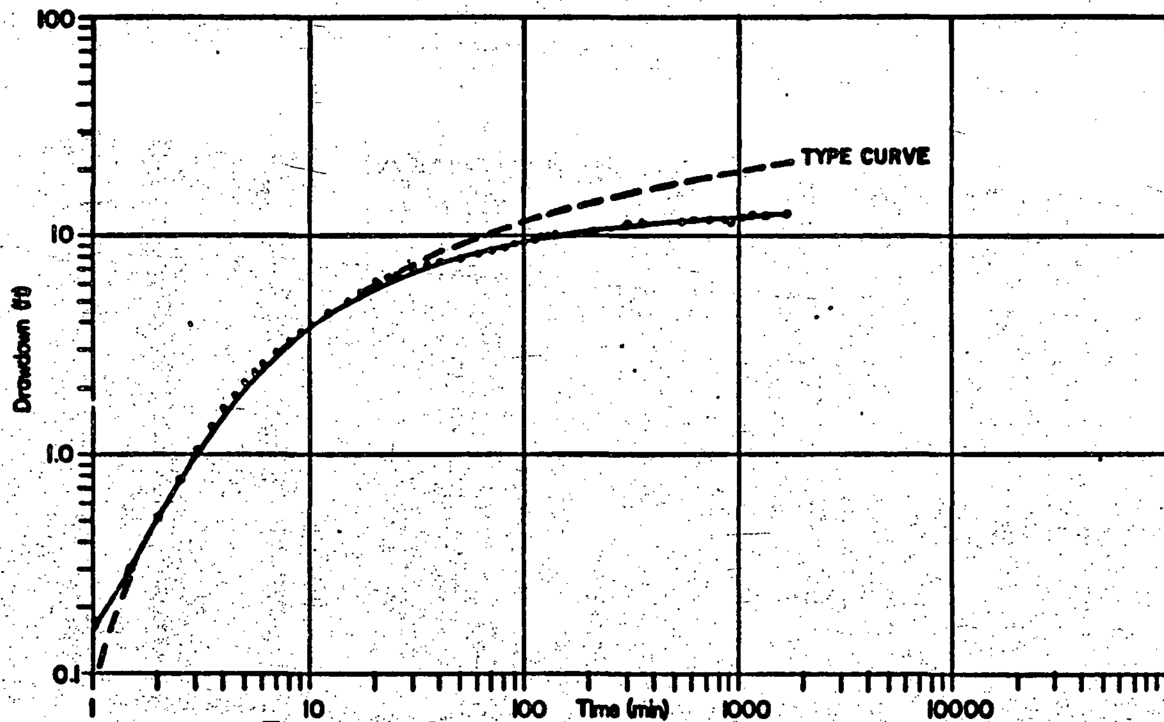
A final calculation was made using the Theis non-equilibrium method as outlined in Johnson Division, U.O.P., Inc. (1982), and applying it to the Kelley well data. Drawdown versus time is plotted on logarithmic paper (Figure 20). The graph is then superimposed on a published "type" curve, so that the plotted points fall on or fit some portion of the type curve. A match point is selected, and from this point the time and drawdown values are used in calculating the aquifer parameters. Transmissivity calculated by this method is 114,600 gpd/ft.

Values of transmissivity and coefficient of storage calculated from all of the above methods are summarized in Table 3. Average values for the aquifer appear to be a transmissivity of 120,000 gpd/ft. and a coefficient of storage of .007.



Drawdown vs Distance From Pumped Well FIGURE#10.

FIGURE#20.



Kelly Well Drawdown vs Time

Table 3 Summary of Transmissivity and Coefficient of Storage Calculations.

Method	Transmissivity (gpd/ft)	Coefficient of Storage	Well Data Used
Jacob-time vs. drawdown	80,000	-	Ranney
"	162,800	0.007	Kelley
"	107,755	0.005	B-1
"	112,340	0.007	B-2
"	128,780	0.009	B-3
Distance vs. drawdown	124,433	0.090	Kelley, B-2
Theis-time vs. drawdown	114,600	0.010	Kelley

It should be noted that when recharge occurs, the straight line of a distance-drawdown plot is displaced upward, while its slope remains the same (Johnson Div., U.O.P. Inc., 1982). While the transmissivity calculation is unaffected, the displacement results in a coefficient of storage value that is higher than the correct one. This is another indication that a recharge boundary has been encountered.

Figures 21 and 22 show contour maps of the water table under pumping and recovery conditions, compiled from data obtained during the aquifer test. The map of the water table under pumping conditions was constructed from water level measurements taken prior to shutting off the Ranney well. The Ranney well had been discharging 3700 gpm for weeks and thus the levels represent a stable condition for that pumping rate. The map shows a portion of a cone of drawdown around the Ranney well that is elongated in a westerly direction. The elongation probably reflects the recharge occurring from the river, as well as the presence of the lacustrine clay to the north.

Figure 22 is a map of water levels representing a 24 hour recovery period. At the end of the period, water levels were still rising, and static conditions had not been attained. The notable feature of this map is that water levels are higher at the Ranney well, than in the vicinity of B-1,B-2, and B-3 to the north. The fairly steep drop in water levels from the north of those wells coincides with the edge of the lacustrine clay, and the ground water contribution to recovery from the direction would be small compared with the area to the south where the effects of the river greatly enhance the recovery. This ground water "trough" would be expected to disappear once full recovery and static conditions had been attained. It appears from these maps that ground water levels north of B-8 and B-10 have been lowered only slightly by the Ranney well discharging at 3700 gpm.

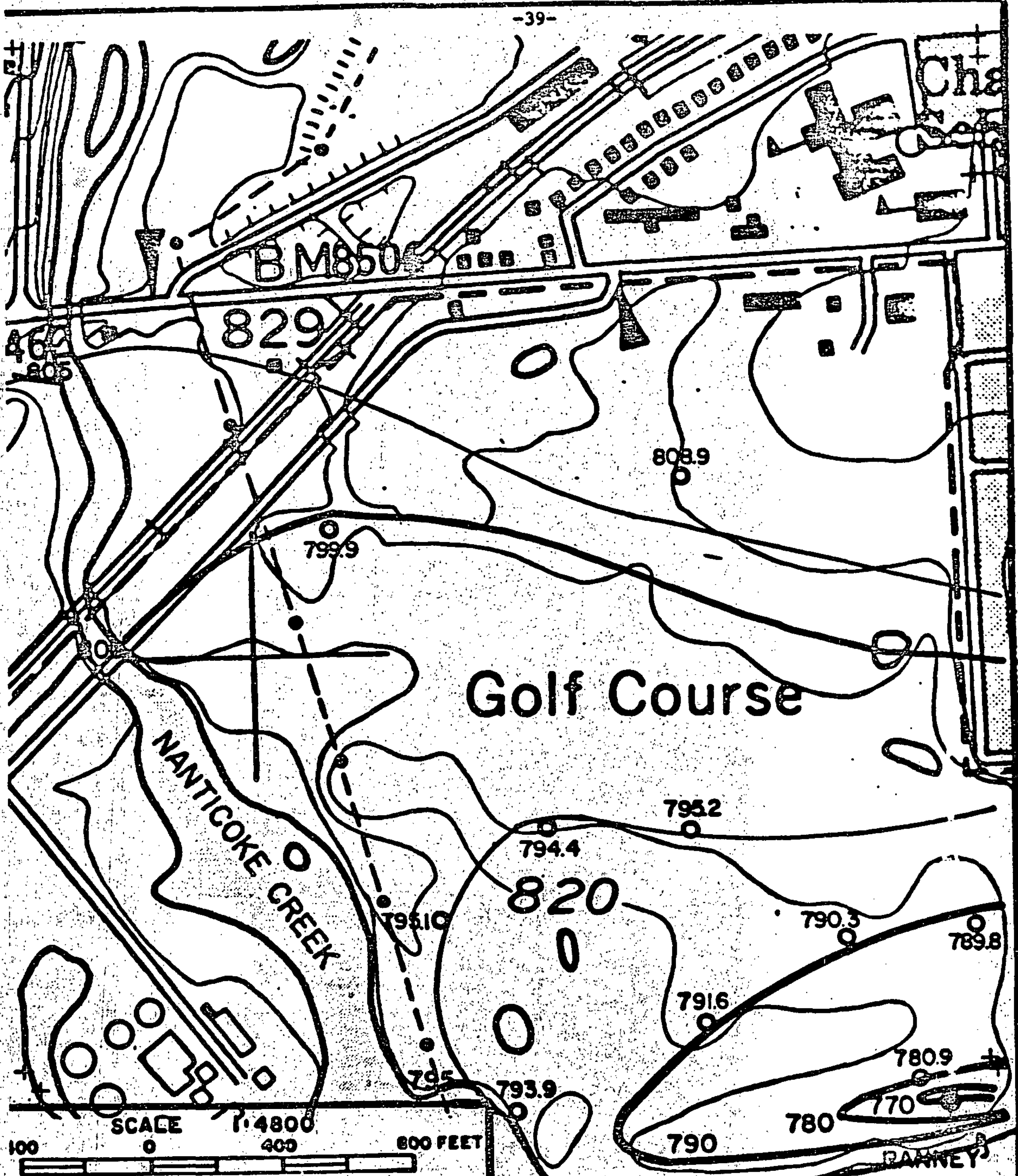


FIGURE #21.
POTENTIOMETRIC SURFACE
WITH RANNEY WELL PUMPING
CONTINUOUSLY AT 3700 GPM

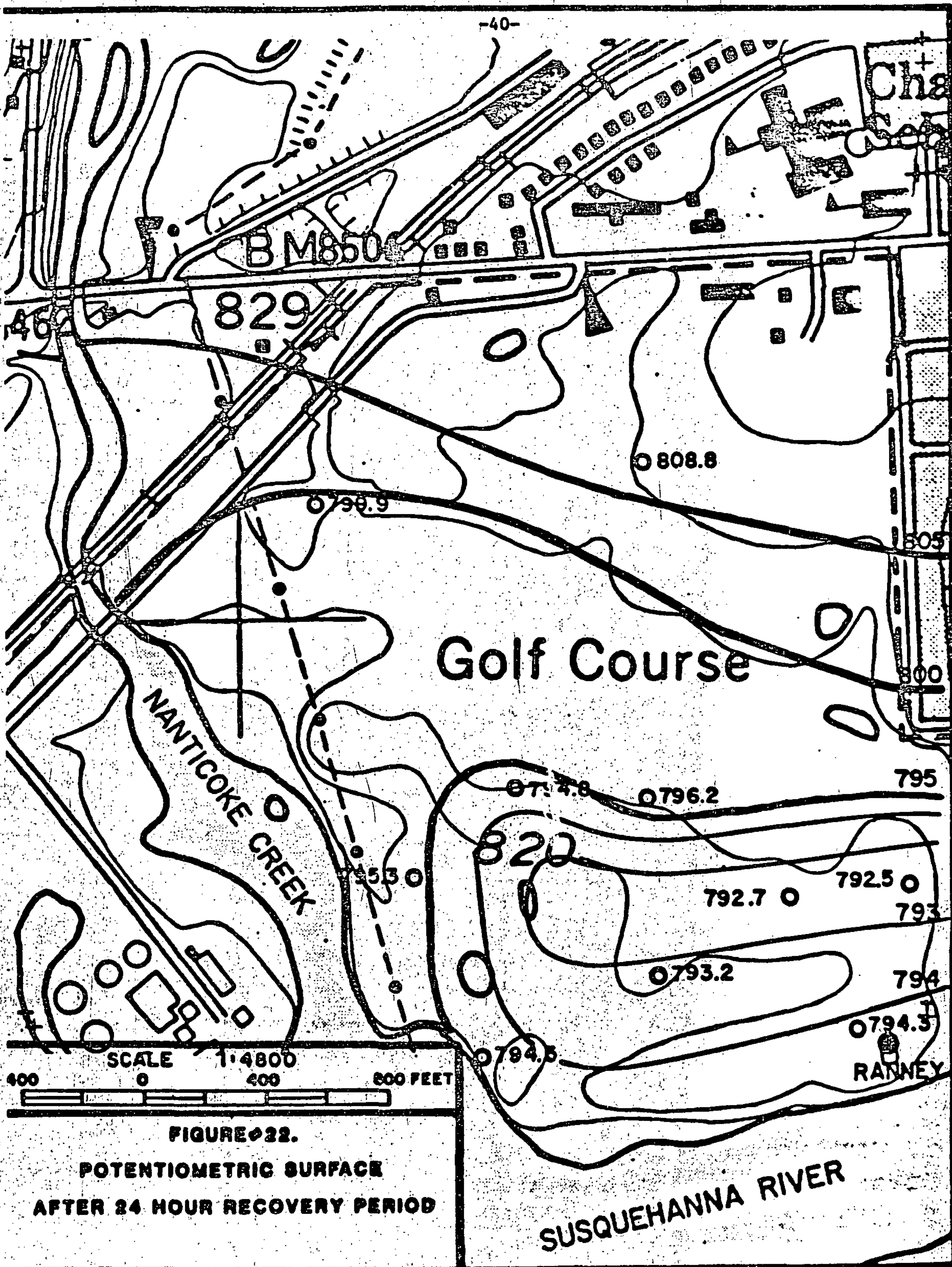


FIGURE 22.
POTENTIOMETRIC SURFACE
AFTER 24 HOUR RECOVERY PERIOD

VI. Contaminant Chemistry

A total of eight organic chemicals have been detected in ground water samples obtained in the vicinity of the Ranney collector well. These chemicals include:

- chloromethane
- vinyl chloride
- chloroethane
- 1,1-dichloroethane
- trans 1,2-dichloroethene
- chloroform
- bromodichloromethane
- trichloroethylene

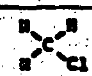
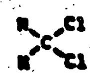
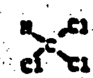
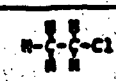
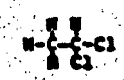
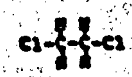
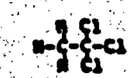
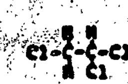
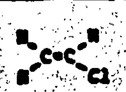
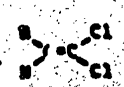
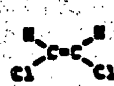
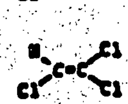
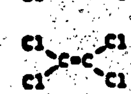
Three alternatives exist which may explain this variety of chemical constituents. First, a number of chemicals may have been introduced to the aquifer and are migrating independent of one another. Second, one chemical with a number of impurities may have contaminated the aquifer. Or, third, a parent chemical may have undergone biodegradation while in the aquifer, resulting in a number of daughter compounds. It is unlikely that this number of chemicals would be independently disposed of or that a chemical would contain this number of impurities. Thus, the most likely mechanism to explain this variety of chemicals is biodegradation of a parent chemical.

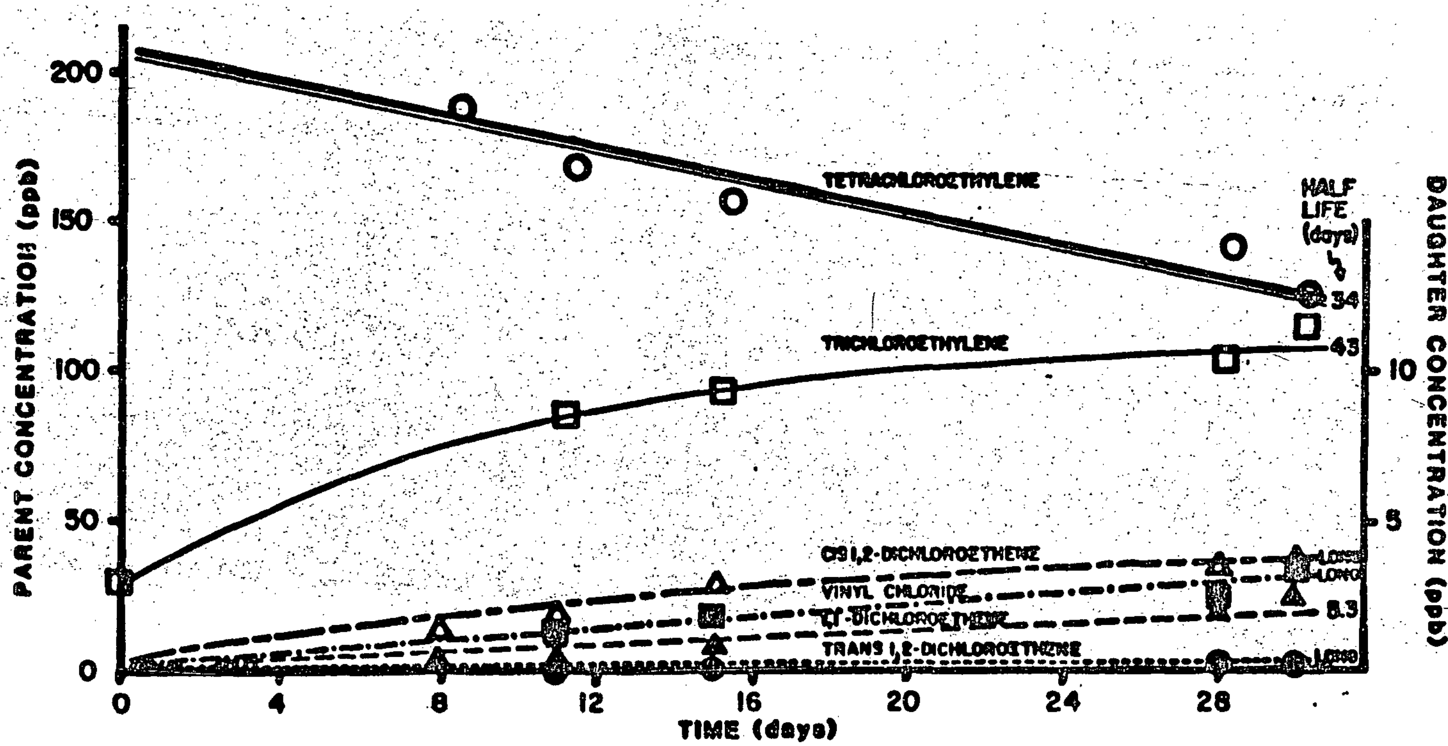
Wood, et al (1981) has demonstrated with both laboratory studies and field data, that certain widely used organic chemicals are unstable in anaerobic aqueous biologic environments. An environment favoring these processes exist in ground water aquifers. Table 4 presents many common chlorinated organic chemicals with their structure and experimental stability. Figure 23 displays data from an experiment where anaerobic biodegradation of tetrachloroethylene was monitored.

The significance of the experimental data to this incident response study is that after a minimal amount of time (with respect to ground water velocities) the daughter chemicals can be found in higher concentrations than the parent chemical. Several of the biodegradation products have long half lives with respect to their parent chemicals and therefore, are persistent in ground water even after the parent compound may be undetectable.

In many cases the migration of landfill leachate may be characterized by elevated concentr[illegible]ions of various inorganic parameters. The leading edge of a l[illegible]chate plu[illegible] [illegible] haracterized by high alkalinity, chloride, hardness and nitrogen species. In reducing conditions, which may be characterized by high ferrous iron, ammonia and sulfide concentration, heavy metals such as copper, cadmium, lead and chromium are mobilized.

TABLE 4 BIODEGRADATION RATES FOR CHLOROMETHANE, CHLOROETHANE AND CHLOROETHENE FAMILIES OF COMPOUNDS IN A MUCK-WATER SAMPLE (from Wood et.al., 1981)

class	compound	molecular structure	half-life in days (200 ug cpd)
Chloromethanes	methyl chloride		<11 (est.)
	methylene chloride		11
	chloroform		36
	carbon tetrachloride		14
Chloroethanes	chloroethane		10
	1,1-dichloroethane		long
	1,2-dichloroethane		long
	1,1,1-trichloroethane		16
	1,1,2-trichloroethane		24
Chloroethenes	vinyl chloride		long
	1,1-dichloroethene		53
	trans 1,2-dichloroethene		long
	cis 1,2-dichloroethene		long
	trichloroethylene		43
	tetrachloroethylene		34



FIGURE#23. DECAY OF TETRACHLOROETHYLENE AND INCREASE OF DAUGHTER COMPOUNDS (FROM WOOD, et. al., 1981)

VII. Discussion

The goals of the incident response study were to identify the extent of ground water contamination in the vicinity of the Ranney well, if possible determine and eliminate the source of contamination, and formulate a remediation plan to minimize the effects of contamination on the Village of Endicott's water supply. During the course of the study, as a result of time and financial constraints, it has been necessary to modify these objectives. However, throughout the study the continued use of the Ranney production well has been the primary concern.

Stratigraphic information available prior to the initiation of this field study was limited to areas around the perimeter of the study area. The monitoring well installation helped define the stratigraphy and aquifer geometry within the specific study area, in addition to the primary purposes, which were to provide locations for ground water sampling, in an effort to delineate the contamination plume, and determine the potentiometric surface and ground water flow directions. These three purposes for monitoring well installation became an integrated task. It was necessary to determine the stratigraphic units in which contamination exists, define the aerial and vertical extent of these units, and resolve the flow direction between the units in an effort to determine the origin of the contamination.

The existence of a kettle hole in the southwest corner of the golf course was indicated from prior surficial geological mapping (Holecek, et al, 1982). The stratigraphic sequence within the kettle hole structure, and the contact between it and the outwash-ice-contact sands and gravels needed to be determined. Evidence from the logs of the monitoring wells placed the contact between wells B-12 and B-3 (Figure 7). The stratigraphic sequence in the kettle hole consists of organic silt and clay overlying fine gray sand with a trace of gravel. Significant organic contamination was found in the fine gray sand and gravel in B-12 and in the brown sand and gravel in B-3, indicating hydraulic connection between these two stratigraphic units.

Continuous pumping of the Ranney well has had a significant impact on configuration of the potentiometric surface. The area of influence of the well has been shown to be skewed to the west and northwest, with minimal impact in the northern direction. This elongated shape is controlled by the aquifer geometry, as well as by the presence of the river acting as a recharge source. A band of highly conductive material is present parallel to the river. This material is bordered to the north by a less conductive, massive silt and clay layer.

The recovery portion of the aquifer pumping test indicated that the majority of the recharge originated from the river (Figure 22). If full recovery was allowed to take place, the resulting potentiometric surface in the western portion of the golf course would indicate a south to southwest direction of ground water flow, toward the river and Nanticoke Ck. Therefore, it can be reasonably stated that the discharge of 3700 gpm at the Ranney well is controlling ground water flow in the southern third of the golf course area.

In the area of highest observed contamination, the ground water flow direction during continuous pumping, as defined by the potentiometric surface, is from northwest to southeast. It is apparent that the contamination present at well B-12 is originating from, or migrating through the semi-confined layer of fine gray sand and gravel beneath the kettle hole, and continuing through the outwash and ice-contact sand and gravel to the east. This flow direction may be noted in the west-east cross section (figure #8) as traveling from the kettle hole material into the sand and gravel deposits to the east.

Contaminants have many properties which control their distribution within an aquifer. These properties include specific gravity and solubility. Generally, the contaminants present in the monitoring wells have higher specific gravities than water, and are slightly soluble. Therefore, they should tend to migrate within the saturated thickness of the aquifer with a slightly downward flow component. Low level contaminants however, do not always follow expected patterns. It can be concluded that the plume is at least 11 feet thick at the point where it enters the laterals of the Ranney well, because contamination is entering from the two top tiers of laterals. The actual thickness of the plume probably is greater than 11 feet, extending above the top tier of laterals. Closer to the source of contamination the thickness of the plume would be expected to decrease.

In order to determine the plume thickness it would be necessary to install a nested well series. This consists of a number of wells installed in close proximity, and screened at various intervals within the saturated thickness of the aquifer. The distance between the upper and lower-most screened intervals that contain contamination is assumed to be the vertical thickness of the plume at that point.

The chemistry of the contaminants was discussed in a previous section within this report. There exist a few inconsistencies between actual field data and what should be expected for the system that has been described. It is characterized by the source chemical(s), either tetrachloroethylene and/or trichloroethylene, undergoing biodegradation in a near anaerobic aqueous environment. The daughter products of biodegradation of these chemicals are lower molecular weight chlorinated ethenes, ethanes and methanes. Some of the daughter products are more stable than the parent compound while others are less stable and degrade into other generations of daughter products.

Stable daughter products from the biodegradation of the source chemicals include vinyl chloride, cis and trans-1,2-dichloroethylene. The cis isomer predominates in ground water due to biodegradation favoring its formation over the trans isomer in approximately a 25:1 ratio. The most unstable daughter compound noted in Wood, et al (1981) is chloroethane. This implies that only minimal concentrations of chloroethane should be found in ground water contaminated with the forementioned parent chemicals. However, significant concentrations of chloroethane have been detected within the plume. In addition, an anomalously high concentration of trichloroethylene was reported in well B-2 on its first sampling, but has not been reported since.

The elevated trichloroethylene concentration may be attributable to laboratory error. However, concentrations of chloroethane have consistently been higher than should be expected. This may suggest the presence of an aqueous environment favoring the stability of chloroethane. The critical factor(s) may be physical and/or chemical. But, the factors present in the fine sands and gravel favor the stability and accumulation of chloroethane.

If the origin of the organic chemicals is a landfill site, elevated concentrations of various inorganic parameters should be expected. Wells B-1 through B-5 were sampled and analyzed for 33 selected inorganic parameters. The analyses are presented in Appendix E. The results reveal increased concentrations of some constituents indicative of landfill leachage in well B-3. However, well B-5 which contains no organic contamination also has elevated concentrations of many of the key constituents found in B-3. It is difficult to correlate the inorganic data with analyses from 601 analyses. The levels of alkalinity and hardness in well B-3 are slightly higher than the other 4 wells sampled; however, they are not above the range which might be expected for uncontaminated ground water in the Endicott area.

In an effort to understand the quantity of chemicals which are responsible for the observed contamination, consideration will be given to the worst case. Well B-12 sampled on 10/27/83 has the highest concentration of organic chemicals of all the observation wells. A total of 457 ug/l (ppb) of organic chemicals were found present using EPA method 601. If we consider a hypothetical aquifer with the dimensions 2000 x 400 x 20 feet and 30 percent porosity, it would contain approximately 1.36×10^8 liters of water. Only 11.2 gallons of pure trichloroethylene would be required to contaminate this hypothetical aquifer at the level found in well B-12. Or, roughly one drum of trichloroethylene has the potential of creating a plume with these concentrations twenty feet thick the size of Enjoie Golf Course.

It is difficult to estimate the quantity of chemicals responsible for the observed contamination at the Ranney well. Even if an extensive drilling program was instituted the parameters required for such calculations may not be available. However, the primary objective of determining the necessary parameters to design the appropriate remedial plan was achieved. As a result of the test well drilling and installation the general flow direction of the contamination is known, the aquifer parameters necessary to design a remedial action plan have been established, and the extent of contamination in the vicinity of the Ranney well has been determined. In addition, the test drilling has refined the understanding of aquifer geometry in the southern portion of the golf course. These factors all contribute to establishing an accurate interpretation of contaminant flow within the vicinity of the Ranney well.

The study has determined that the contamination is migrating to the Ranney well from the northwest. It appears that contaminants could easily migrate in this direction under Nanticoke Creek with minimal dilution from surface infiltration. This is due to the presence of an impermeable clay layer separating the creek from the permeable sand and gravel strata. This clay layer is encountered in test wells B-4,B-9,B-11, and B-12. The contamination would be migrating in the flow directions following the hydraulic gradient indicated in Figure #21. Contaminants originating northwest of wells B-4 and B-10 might also migrate beneath Nanticoke Creek, although there is no evidence at present for an impermeable layer in that vicinity. If so, dilution of contaminated ground water may occur as it moves underneath the influent stream. The placement of monitoring wells on the west bank of the Nanticoke Creek could further confirm the flow direction and hydraulic gradient northwest of the contaminated area of the golf course.

The Enjoie Golf Course is bordered on the west and northwest by inactive municipal landfills. Although it is conceivable that the source of contamination is one or more of these landfills they should not be considered the only possibilities. An alternative source of contamination may be the illegal dumping of toxic chemicals. If the dumping occurred along the Airport Road or the access road to the sewage plant it would be difficult if not impossible, to distinguish this as a source from toxic waste buried in one of the adjacent landfills.

This uncertainty points out the need for future exploratory drilling. The drilling should be performed in two phases. The first phase should be concentrated on the east side of the Nanticoke Creek. Well B-4 should be deepened and additional wells placed to the north and south of this site. The second phase of drilling should focus on the west side of Nanticoke Creek. The wells should be correlated with those containing contamination on the east bank. These additional wells will further determine aquifer geometry, delineate contamination and establish the potentiometric surface and flow direction in the vicinity of Nanticoke Creek.

A remediation plan to minimize the effects of contamination on the water supply remains a primary goal of this study. There appear to be three options worthy of consideration. The first option would be to maintain the present aeration and sampling program. Since the installation of air stripping equipment, vinyl chloride concentrations have not exceeded the NYSDOH guideline of 5 ppb. Sampling would continue whether or not other options were implemented. The equipment is already in place and the only additional cost would be for the operation and maintenance of the aeration equipment. The disadvantage of this alternative is that it provides for no other option but to close the well if vinyl chloride or other chemical concentrations reach critical levels.

The second option would be the treatment of drinking water after it is withdrawn from the ground and before it enters the distribution system. This could be accomplished by the use of a packed tower and/or an activated carbon filter. This type of system would insure the removal of chlorinated organics from drinking water. It could be used as a secondary system and only operated when vinyl chloride levels exceeded a predetermined value. Or, all drinking water could be treated with the system and the present aeration equipment would remain in place as a back up system.

The third alternative involves the interception and treatment of contamination before it enters the Ranney Collector well. This would be accomplished by the installation of a purge well. The well would be placed in a position where it would intercept contamination migrating toward the Ranney well. Present information indicates a purge well could be located in the area between wells B-3 and B-12 to accomplish this task. The well could be designed to serve a multiple purpose. During the spring, summer and fall the golf course requires water for irrigation. Presently, they are using municipal water for this purpose. Discharge from the purge well could be used for irrigation, when required, and/or aerated and discharged to the Susquehanna when not required, provided that effluent limitations could be met. Additional exploratory drilling would be required to determine the vertical extent of contamination in addition to other factors critical for proper well design. The purge well could be used as a primary treatment method and the in well aeration equipment would be available if this system failed or contaminant concentrations reached critical levels.

The selection of a remediation plan will depend on the degree of confidence each system or systems promotes and the fiscal constraints under which a system must be installed. It is the recommendation of this report that an option be implemented which provides an alternative in the event one system fails. Such an option would exist with either the second or third alternative. The water production of the Ranney well is crucial to the Village's supply system. The continued operation of the Ranney Collector well is imperative.

VIII. Conclusions and Recommendations

1) The source of the contamination is located west or northwest of the Ranney Collector well. Suspected sources include the inactive municipal landfills adjacent to the Enjoie Golf Course, and/or the illegal dumping of toxic chemicals off roads at the west and northwest perimeter of the course. It may be impossible to distinguish between these sources.

2) The aquifer supplying the Ranney Collector well consists of highly permeable sand and gravel deposits with a saturated thickness on the order of 80 feet. The aquifer is limited in its northern extent, being bordered in large part by a massive silt and clay layer, but is extensive in the east-west direction. Analysis of the pumping test data indicates a transmissivity for the aquifer of 120,000 gpd/ft and a coefficient of storage of 0.007. The aquifers exhibit a good hydraulic connection with the river, and after about 20 minutes of pumping at 3700 gpm, the Ranney well is deriving approximately 90 percent of its water from recharge from the river.

3) The ground water flow direction in the southern portion of the golf course is to the east and southeast in response to the pumping of the Ranney well. There may be underflow of ground water from the west side of Nanticoke Creek in response to the pumping of the Ranney well, however more field testing would be required to firmly establish this.

4) The source chemical(s) is suspected of being tetrachloroethylene and/or trichloroethylene. These chemicals undergo rapid biodegradation to form lower molecular weight chlorinated ethenes, ethanes, and methanes. These daughter products may be subject to further biodegradation. The resulting array of contaminants may be found to exceed the concentration of the parent compound some distance from the source.

5) The weekly sampling program should be continued to insure compliance with NYSDOH drinking water guidelines.

6) The aeration program should be continued in an effort to maintain compliance with NYSDOH drinking water guidelines until an alternative remediation program(s) is enacted.

7) Periodic raw water analyses should be conducted on the Ranney well in order to determine the effectiveness of the present diffused air system.

8) A remediation plan must be chosen which provides the security of an alternative option which may be implemented in the event of a system failure, or used in conjunction with the primary remedial plan if contamination reaches critical levels. The most attractive alternative to obtain this goal appears to be the installation of a purge well to intercept contaminated groundwater. This alternative could serve a multiple purpose for both the golf course and the Village of Endicott.

9) Additional drilling and monitoring well installation is advised. The drilling should be conducted in two phases. The first phase should include installation of monitoring wells on the east bank of Nanticoke

Creek, and the second phase should provide for the installation of wells on the west bank complementary to those containing contamination on the east bank.

10) The continued operation of the Ranney collector well is imperative. The quantity of water produced by the Ranney well cannot be replaced by existing wells in the Village of Endicott's water supply system.

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X. Appendices

Appendix A

Title 6 of the NYSDEC, Official Compilation of Codes, Rules and Regulations, Part 703.

GROUND WATER CLASSIFICATIONS

QUALITY STANDARDS

AND

EFFLUENT STANDARDS AND/OR LIMITATIONS

(Title 6, Official Compilation of Codes, Rules and Regulations, Part 703)

NEW YORK STATE

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

(Effective September 1, 1978)

Section 703.5 Classes and quality standards for ground waters.

(a) Class GA

(1) The best usage of Class GA waters is as a source of potable water supply. Class GA waters are fresh ground waters found in the saturated zone of unconsolidated deposits and consolidated rock or bed rock.

(2) Quality standards for class GA waters shall be the most stringent of:

(i) the items and specifications applicable to such waters found in this section;
(ii) the maximum contaminant levels for drinking water promulgated by the Commissioner of Health as found in 10 NYCRR Subpart 5-1, Public Water Supplies or any subsequent revision thereto or replacement thereof;
(iii) the maximum contaminant levels for drinking water promulgated by the Administrator under the Safe Drinking Water Act (P.L. 93-523) ; and
(iv) the standards for raw water quality promulgated by the Commissioner of Health as found in 10 NYCRR Part 170, Sources of Water Supply or any subsequent revision thereto or replacement thereof.

(3) The following quality standards shall be applicable to Class GA waters.

Items	Specifications
1. Sewage, industrial waste or other wastes, taste or odor producing substances, toxic pollutants, thermal discharges, radioactive substances or other deleterious matter.	1. None which may impair the quality of the ground waters to render them unsafe or unsuitable for a potable water supply or which may cause or contribute to a condition in contravention of standards for other classified waters of the State.
2. The concentration of the following substances or chemicals:	2. Shall not be greater than the limit specified, except where exceeded due to natural conditions:
(1) Arsenic (As)	(1) 0.025 mg/l
(2) Barium (Ba)	(2) 1.0 mg/l
(3) Cadmium (Cd)	(3) 0.01 mg/l
(4) Chloride (Cl)	(4) 250 mg/l
(5) Chromium(Cr) Hexavalent	(5) 0.05 mg/l
(6) Copper (Cu)	(6) 1.0 mg/l
(7) Cyanide (CN)	(7) 0.2 mg/l
(8) Fluoride (F)	(8) 1.5 mg/l
(9) Foaming Agents[1]	(9) 0.5 mg/l
(10) Iron (Fe)[2]	(10) 0.3 mg/l

(11) Lead (Pb)	(11) 0.025 mg/1
(12) Manganese (Mn)[2]	(12) 0.3 mg/1
(13) Mercury (Hg)	(13) 0.002 mg/1
(14) Nitrate (as N)	(14) 10.0 mg/1
(15) Phenols	(15) 0.001 mg/1
(16) Selenium (Se)	(16) 0.02 mg/1
(17) Silver (Ag)	(17) 0.05 mg/1
(18) Sulfate (SO_4)	(18) 250 mg/1
(19) Zinc (Zn)	(19) 5 mg/1
(20) pH Range	(20) 6.5-8.5
(21) Aldrin, or 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-<u>endo</u>-1, <u>4</u>-exo-5, 8-dimethanonaphthalene.	(21) not detectable [3]
(22) Chlordane, or 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene.	(22) 0.1 ug/1
(23) DDT, or 2,2-bis- (p-chlorophenyl)-1,1,1-trichloroethane and metabolites.	(23) not detectable [3]
(24) Dieldrin, or 6,7-epoxy aldrin.	(24) not detectable [3]
(25) Endrin, or 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo-1,4-<u>endo</u>-5,8-dimethanonaphthalene.	(25) not detectable [3]
(26) Heptachlor, or 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,<u>7</u>-methanoindene. and metabolites.	(26) not detectable [3]
(27) Lindane and other Hexachlorocyclohexanes or mixed isomers of 1,2,3,4,5,6-hexachlorocyclohexane.	(27) not detectable [3]
(28) Methoxychlor, or 2,2-<u>bis</u>-(<u>p</u>-methoxyphenyl)-1,1,1-trichloroethane.	(28) 35.0 ug/1
(29) Toxaphene (a mixture of at least 175 chlorinated camphene derivatives).	(29) not detectable [3]
(30) 2,4-Dichlorophenoxyacetic acid (2,4-D)	(30) 4.4 ug/1
(31) 2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP) (Silvex)	(31) 0.26 ug/1

(32) Vinyl chloride (chloroethene)	(32) 5.0 ug/l
(33) Benzene	(33) not detectable [3]
(34) Benzo(a) pyrene	(34) not detectable [3]
(35) Kepone or decachlorooctahydro-1,3,4-metheno-2H-cyclobuta (cd) pentalen-2-one (chlordecone).	(35) not detectable [3]
(36) Polychlorinated biphenyls (PCB) (Aroclor)	(36) 0.1 ug/l
(37) Ethylene thiourea (ETU)	(37) not detectable [3]
(38) Chloroform	(38) 100 ug/l
(39) Carbon tetrachloride (tetrachloromethane)	(39) 5 ug/l
(40) Pentachloronitrobenzene (PCNB)	(40) not detectable [3]
(41) Trichloroethylene	(41) 10 ug/l
(42) Diphenylhydrazine	(42) not detectable [3]
(43) bis (2-chloroethyl) ether	(43) 1.0 ug/l
(44) 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)	(44) 35 ug/l
(45) 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	(45) 3.5×10^{-5} ug/l
(46) 2-Methyl-4-chlorophenoxyacetic acid (MCPA)	(46) 0.44 ug/l
(47) Amiben, or 3-amino-2,5-dichlorobenzoic acid (chloramben)	(47) 87.5 ug/l
(48) Dicamba, or 2-methoxy-3,6-dichlorobenzoic acid	(48) 0.44 ug/l
(49) Alachlor, or 2-chloro-2',6'-diethyl-N-(meth oxymethyl)-acetanilide (Lasso)	(49) 35.0 ug/l
(50) Butachlor, or 2-chloro-2',6'-diethyl-N-(butoxymethyl)-acetanilide (Machete).	(50) 3.5 ug/l
(51) Propachlor, or 2-chlor-N-isopropyl-N-acetanilide (Ramrod)	(51) 35.0 ug/l
(52) Propanil, or 3',4'-dichloropropionanilide	(52) 7.0 ug/l
(53) Aldicarb, [2-methyl-2-(methylthio) propionaldehyde O-(methyl carbamoyl) oxime] and methomyl [1-methylthioacetaldehyde O-(methyl-carbamoyl) oxime]	(53) 0.35 ug/l

(54)	Bromacil, or 5-broma-3-sec-butyl-6-methluracil	(54)	4.4 ug/l
(55)	Paraquat, or 1,1'-dimethyl-4,4'-dipyridylium	(55)	2.98 ug/l
(56)	Trifluralin, or α,α,α-trifluoro-2,6-dinitro-N-dipropyl-p-toluidine (Treflan)	(56)	35.0 ug/l
(57)	Nitralin, or 4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline (Planavin)	(57)	35.0 ug/l
(58)	Benefin, or N-butyl-N-ethyl-α,α,α-trifluoro-2,6-dinitro-p-toluidine (Balan)	(58)	35.0 ug/l
(59)	Azinphosmethyl, or O,O-dimethyl-S-4-oxo-1,2,3-benzotriazin-3(4H)-ylmethylphosphorodithioate (Guthion)	(59)	4.4 ug/l
(60)	Diazinon, or O,O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl)-phosphorothioate.	(60)	0.7 ug/l
(61)	Phorate (also for Disulfoton), or O,O-diethyl-S-[(ethylthio)methyl]-phosphorodithioate (Thimet R), and disulfoton, or O,O-diethyl-S-[(2-ethylthio)ethyl] phosphorodithioate (Di-System R)	(61)	not detectable [3]
(62)	Carbaryl, or 1-naphthyl-N-methylcarbamate	(62)	28.7 ug/l
(63)	Ziram, or zinc salts of dimethyldithiocarbamic acid.	(63)	4.18 ug/l
(64)	Ferbam, or iron salts of dimethyldithiocarbamic acid.	(64)	4.18 ug/l
(65)	Captan, or N-trichloromethylthio-4-cyclohexene-1,2-dicarboximide.	(65)	17.5 ug/l
(66)	Folpet, or N-trichloromethylthiophthalimide.	(66)	56.0 ug/l
(67)	Hexachlorobenzene (HCB)	(67)	0.35 ug/l
(68)	Paradichlorobenzene (PDB)(also orthodichlorobenzene)	(68)	4.7 ug/l
(69)	Parathion (and Methyl parathion), or (O,-O-diethyl-O-p-nitrophenylphosphorthioate, and methyl parathion, or O,O-dimethyl-O-p-nitrophenylphosphorothioate.	(69)	1.5 ug/l
(70)	Malathion, or S-1,2-bis (ethoxycarbonyl) ethyl-O,O-dimethylphosphorodithioate.	(70)	7.0 ug/l
(71)	Maneb, or manganese salt of ethylene-bis-dithiocarbamic acid.	(71)	1.75 ug/l

(72)	Zineb, or zinc salt of ethylene-bis-dithiocarbamic acid.	(72)	1.75 ug/l
(73)	Dithane, or zincate of manganese ethylene-bis-dithiocarbamate.	(73)	1.75 ug/l
(74)	Thiram, or tetramethylthiuramdisulfide	(74)	1.75 ug/l
(75)	Atrazine, or 2-chloro-4-ethylamino-6-isopropylamino-S-triazine.	(75)	7.5 ug/l
(76)	Propazine, or 2-chloro-4,6-diisopropyl-amino-S-triazine.	(76)	16.0 ug/l
(77)	Simazine, or 2-chloro-4,6-diethylamino-S-triazine.	(77)	75.25 ug/l
(78)	di-n-butylphthalate	(78)	770 ug/l
(79)	Di (2-ethylhexyl) phthalate (DEHP)	(79)	4.2 mg/l
(80)	Hexachlorophene, or 2,2'-methylene-bis (3,4,6-trichlorophenol)	(80)	7 ug/l
(81)	Methyl methacrylate	(81)	0.7 mg/l
(82)	Pentachlorophenol (PCP)	(82)	21 ug/l
(83)	Styrene	(83)	931 ug/l

<u>Notes:</u>

1. Foaming agents determined as methylene blue active substances (MBAS) or other tests as specified by the Commissioner.
2. Combined concentration of iron and manganese shall not exceed 0.5 mg/l.
3. "Not detectable" means by tests or analytical determinations referenced in Section 703.4.

Appendix B

Logs of Selected Wells
and borings

Appendix B
Logs of Monitoring Wells and Test Borings

Test Hole #1 (B-1)

Depth: 70 ft. Bottom of 5 ft. screen set at 60 ft. Sampled at 5 ft. intervals

0-16 ft.	Brown fine sand, some silt, trace of clay
16-175	Gravel, medium sand
17.5-22.5	Brown medium sand
22.5-27.5	Brown medium sand, medium-fine gravel, wet
27.5-52-5	Brown medium-coarse sand, medium coarse gravel
52.5-70	Same with a trace of clay

Water level 29'3"

Test Hole #2 (B-2)

Depth: 60 ft. Bottom of 5 ft. screen set at 60 ft. Sampled at 10 ft. intervals

0-5 ft	Tan moist silt, trace of fine sand
5-15	Brown medium-fine gravel, some sand, trace silt
15-35	Brown medium-coarse sand, medium gravel, trace silt
35-45	Medium gravel, some sand, wet
45-55	Gray medium-coarse sand, fine medium gravel, trace silt
55-60	Gray brown medium-fine sand, trace silt

Water level 28'1"

Test Hole #3 (B-3)

Depth: 60 ft. Bottom of 5 ft. screen set at 55 ft. Sampled at 10 ft. intervals

0-9 ft.	Brown fine silt
9-15	Brown coarse-medium sand, some medium-fine gravel
15-45	Medium-fine gravel, some medium-fine brown sand, wet at 21.5 ft.
45-55	Gravy-brown medium-fine saturated sand, trace gravel
55-60	Brown saturated fine sand, trace coarse sand

Water level 23'8"

Test Hole #4 (B-4)

Depth: 50 ft. Bottom of 5 ft. screen set at 50 ft. Sampled at 10 ft. intervals

0-10 ft.	Brown clay
10-28	Gray clay, some silt
28-30	Gravel
30-40	Brown fine sand and silt, some clay
40-50	Gray medium-fine sand, trace medium gravel, wet.

Water level 15'11"

Test Hole #5 (B-5)

Depth: 50 ft. Bottom of 5 ft. screen set at 50 ft. Sampled at 10 ft. intervals

0-18 ft.	Brown fine-medium sand, some gravel
18-30	Medium-coarse gravel, brown fine sand and silt, trace clay, wet
30-42	Fine-coarse gravel, brown fine-coarse sand, silt, clay, dense (till?)
42-50	Medium-coarse gravel, fine brown sand, silt, clay, looser than above and wet

Water level 16'

Test Hole #6 (B-6)

Depth: 50 ft. Bottom of 5 ft. screen set at 40 ft. Sampled at 10 ft. intervals

0-15 ft.	Brown medium-coarse sand, fine-medium gravel, wet at 10 ft.
15-25	Brown fine-medium sand, some red clay and silt
25-41	Brown fine sand, fine-coarse gravel, some silt
41-50	Gray clay

Water level 23'4"

Test Hole #7 (B-7)

Depth: 50 ft. Too little water for sampling. Hole abandoned and backfilled.
Sampled at 10 ft. intervals

0-18 ft.	Gray-brown silt, little clay
18-19	Medium gravel, wet
19-50	Gray clay

Test Hole #8 (B-8)

Depth: 40 ft. Bottom of 5 ft. screen set at 28 ft. Sampled 10 ft. intervals to 20 ft., continuous sampling to 30 ft.

0-5 ft.	Brown silt
5-24	Brown silt
24-26	Medium-coarse gravel
26-28	Medium gravel and coarse brown sand
28-40	Gray clay

Water level 24'4"

Test Hole #9 (B-9)

Depth: 50 ft. Bottom of 5 ft. screen set at 50 ft. Sampled at 10 ft. intervals

0-17 ft.	Brown fine silty sand, little clay
17-41	Gray silt, and clay
41-50	Gray fine-medium sand, wet at 42 ft.

Water level 20'2"

Test Hole #10 (B-10)

Depth: 52 ft. Bottom of 5 ft. screen set at 50 ft. Sampled at 10 ft. intervals

0-5 ft.	Brown dense silt
5-36	Medium-coarse gravel, brown fine-medium sand, some silt, wet at 30 ft.
36-51	Brown medium-fine sand, some silt
51-52	Gray clay

Water level 26'7"

Test Hole #11 (B-11)

Depth: 65 ft. Bottom of 5 ft. screen set at 65 ft. Log from cuttings.

0-17 ft.	Brown fine silty sand, little clay
17-41	Gray silt, and clay
41-65	Gray fine-medium sand

Test Hole #12 (B-12)

Depth: 65 ft. Bottom of 5 ft. screen set at 65 ft. Log from cuttings.

0-10 ft.	Brown fine sand
10-20	Gray clay and silt
20-65	Gray fine snad, and gravel

Test Hole #13 (B-13)

Depth 65 ft. Bottom of 5 ft. screen set at 63 ft. Log from cuttings.

0-5 ft.	Brown fine sand and silt
5-10	Brown fine sand and bright medium gravel, trace silt
10-40	Bright fine to medium gravel, some brown fine to medium sand
40-65	Brown medium sand, some fine gravel

Test Borings

4205 30 7604 49

Depth: 135 ft.

0-30 ft.	Clay, gravel, and sand
30-40	Sand and gravel
40-135	Clay

4205 10 7605 20

Depth: 71 ft.

0-6 ft.	Silt, brown, medium, some vegetation
6-19	Gravel and coarse sand, trace silt, firm brown
19-56	Medium to fine sand, gray, firm
56-71	Medium gravel, some silt, compact, brown

Ranney Well

Depth: 97 ft.

0- 8 ft.	Gray clay and silt, and vegetation
8-25 ft.	Gravel, pebbles and cobbles, and medium to very coarse sand
25-35 ft.	Blue clay and silt, with some gravel and sand
35-53 ft.	Gravel pebbles and cobbles, and fine to very coarse sand
53-60 ft.	Pea gravel, coarse sand, some cobbles
60-75 ft.	Clay, silt, and fine to medium sand
75-79 ft.	Gravel, chiefly cobbles
79-82 ft.	Sand, fine to very coarse, gray, pebbly
82-96 ft.	Gravel, pebbles and cobbles and fine to very fine coarse sand
96-97 ft.	Clay, silt, sand, gravel; hard
97- ft.	Rock

Kelley Well

Depth: 100 ft.

0-10 ft.	Clay and sand
10-20 ft.	Gravel, coarse
20-60 ft.	Sand, fine and gravel
60-71 ft.	Gravel, coarse, much water
71-89 ft.	Gravel, coarse, and boulders
89-93 ft.	Sand, coarse, and clay
93-100 ft.	Gravel, much water

Appendix C

29 Priority Pollutants Analyzed for
in EPA Method 601

APPENDIX C

29 Priority Pollutants Analyzed for in EPA Method 601

Chloromethane
Bromomethane
Vinyl Chloride
Dichlorodifluormethane
Chloroethane
Trichlorofluoromethane
Dichloromethane
1,1-Dichloroethene
1,1-Dichloroethane
Trans-1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
1,1,1-Trichloroethane
Carbon Tetrachloride
Bromodichloromethane
1,2-Dichloropropane
Trans-1,3-Dichloropropene
Trichloroethylene
Dibromochloromethane
Cis-1,3-Dichloropropene
1,1,2-Trichloroethane
2-Chloroethylvinyl Ether
Bromoform
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Chlorobenzene
1,3-Dichlorobenzene
1,2-Dichlorobenzene
1,4-Dichlorobenzene

Appendix D

Laboratory Analyses of Ground Water Samples (Organic Constituents)

Appendix D

Summary of Positive Organic Chemical Sample Results

Date	Location	Lab.	Chloroform	Bromodi-Chloromethane	Dibromo-Chloromethane	Vinyl Chloride	1,1-Dichloro-ethane	cis/Trans-1,2 dichloro-ethylene	1,1,1-Trichloro-ethane	Trichloro-ethylene
12/10/80	Well 5	DOH		2.0	2.0	NA	NA	NA	2.0	
"	Ranney	"				NA	NA	NA		
1/7/81	Well 5	"				NA	NA	NA	2.0	
5/11/81	Ranney	EPA				8.4				
7/23/81	Wells 5&28	DOH	2.3	1.1					1.7	
2/23/82	Ranney	EPA	0.6	0.34		7.5	3.5	6.0	1.1	1.4
"	Well 28	"				1.6	0.55	2.1	0.41	
"	Robble Ave.	"	0.86	0.57		5.6	3.1	5.4	1.1	1.3
9/28/82	Ranney	DOH	1.0				2.0	6.0		
"	Well 28	"						3.0		
11/9/82	Robble Ave.	"	1.0			2.0	4.0	7.0	8.0	2.0
"	Ranney	"	1.0			3.0	4.0	7.0	5.0	2.0
"	Well 28	"					1.0	5.0		
12/13/82	Well 28	"				1.0		4.0	1.0	
"	Ranney	"	2.0			3.0	3.0	5.0	2.0	2.0
"	Robble Ave.	"	2.0	1.0		3.0	3.0	5.0	2.0	2.0
1/18/83	Well 28	"					1.0	3.0		
"	Ranney	"	1.0	1.0		3.0	3.0	5.0	1.0	2.0
"	Robble Ave.	"	1.0			1.0	2.0	4.0		1.0
"	Boswell Hill	"	1.0	1.0		1.0	2.0	4.0	1.0	1.0
1/27/83	Ranney	"	1.0			2.0	2.0	5.0	1.0	5.0
"	Lateral A-7	"	1.0				2.0	3.0	2.0	3.0

12/10/80 to 5/10/83
All results in parts per billion
Wells 5 & 28 are at South St. well field

Robble Ave. & Boswell Hill are pumping stations

A blank indicates "not detected"

NA means "not analyzed for"

Appendix D (cont'd)

Summary of Positive Organic Chemical Sample Results

Date	Location	Lab.	Chloroform	Bromodi-Chloromethane	Dibromo-Chloromethane	Vinyl Chloride	1,1-Dichloro-ethane	cis/Trans-1,2 dichloro-ethylene	1,1,1-Trichloro-ethane	Trichloro-ethylene
"	Lateral B-2	DOH	1.0			1.0	2.0	3.0	2.0	3.0
"	Lateral C-1	"				6.0	3.0	10.0		1.0
2/3/83	Lateral D-1	Friend					1.0	1.0		
"	Lateral D-2	"				17.0	5.0	11.0		
"	Lateral D-3	"				17.0	12.0	22.0		
"	Lateral D-4	"				2.0	7.0	9.0		
"	Lateral D-7	"					1.0	2.0		
2/3/83	Lateral C-2	"					2.0	3.0	1.0	
"	Lateral C-3	"					2.0	2.0		
"	Lateral C-4	"					4.0	3.0	1.0	
"	Lateral C-5	"					2.0		1.0	2.0
"	Ranney Tap	"				2.0	2.0	2.0		
2/17/83	"	"				3.0				
"	Lateral D-2	"				10.0	13.0	5.0	5.0	
"	Lateral D-3	"				20.0	8.0	19.0		
"	Lateral D-4	"				4.0	5.0	13.0		
"	Lateral D-8	"				1.0	1.0	1.0		
"	Lateral C-2	"				3.0	3.0	6.0		
"	Lateral C-3	"					3.0	4.0		
3/3/83	Ranney	"				2.0	2.0	5.0		
5/10/83	"	"				2.0	2.0	5.0		
"	Kelley	"				11.0	5.0	18.0		

Appendix D (cont'd)

Summary of Organic Chemical Sample Results 5/10/83 to 10/27/83
(All results in parts per billion)
(All analyses performed by NYSDOH laboratory, Albany, NY)

A blank indicates "not detected"

Date	Location	Vinyl Chloride	Chloro-methane	Chloro-ethane	1,1-Dichloro-ethane	Trans 1,2-Dichloro-ethane	Chloroform	Bromo-Dichloro-Methane	Trichloro-ethylene
5/10/83	Ranney	2.0			2.0	4.0			
"	Golf Course Well								
"	Kelley	6.0		4.0	3.0	12.0			
6/9/83	E Relief Well								
"	W Relief Well								
"	Hancor Well								
6/22/83	B-1	1.0			1.0	9.0	2.0		5.0
"	B-2			1.0		15.0			100.0
"	B-3	110.0		38.0	9.0	84.0			
"	Kelley				3.0	9.0			
6/23/83	Ranney	3.0			3.0	7.0	2.0	2.0	1.0
7/20/83	B-1								
"	B-2				12.0	11.0			4.0
"	B-3	99.0		57.0	10.0	58.0			
"	B-4								
"	B-5								
8/18/83	B-4								
"	B-5								
"	B-6								
"	B-8								
"	B-9 *			3.0					
"	B-10								

Appendix D (cont'd)

Summary of Organic Chemical Sample Results 5/10/83 to 10/27/83
(All results in parts per billion)
(All analyses performed by NYSDOH laboratory, Albany, NY)

Date	Location	Vinyl Chloride	Chloro-methane	Chloro-ethane	1,1-Dichloro-ethane	Trans 1,2 Dichloro-ethane	Chloroform	Bromo-Dichloro-Methane	Trichloro-ethylene
8/19/83	Tier 1 Stop								
9/23/83	B-6								
"	B-8								
"	B-9			2.0					
"	B-10								
10/27/83	B-11		10.0	5.0					
"	B-12	66.0	29.0	280.0	54.0	24.0			4.0
"	B-13	17.0	17.0	50.0	47.0	64.0			1.0

Appendix E

Laboratory Analyses of Ground Water Samples (Inorganic Constituents).

Appendix E
Results Taken on July 20, 1983
(unless otherwise noted sample results are
recorded in miligrams/liter)

Parameter	Well Number B-1	B-2	B-3	B-4	B-5
Zinc	0.48	0.58	2.0	0.88	0.84
Lead, Total	< 0.1	0.3	< 0.1	0.2	0.3
Beryllium, Total	<0.02	<0.02	<0.02	<0.02	<0.02
Copper, Total	0.10	0.40	0.07	0.15	0.35
Nickel, Total	0.11	0.34	0.06	0.06	0.20
Silver, Total	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury*	0.5	1.1	<0.4	<0.4	0.5
Cadmium, Total	<0.02	<0.02	<0.02	<0.02	<0.02
Antimony, Total	< 1.	< 1.	<1.	<1.	<1.
Chromium, Total	<0.1	<0.1	<0.1	<0.1	<0.1
Thallium, Total	<1.	<1.	<1.	<1.	<1.
B.O.D. 5 Day	2.7	3.1	2.6	2.6	1.1
pH	7.8	7.5	7.6	7.8	7.5
Manganese, Total	1.1	0.54	1.1	0.13	0.20
Iron, Total	32.	34.	12.	4.6	19.
Nitrogen, Ammonia	0.23	0.90	0.24	0.040	0.14
Nitrogen, Nitrate & Nitrite	0.30	0.41	<0.05	<0.05	0.91
Sodium, Total	22.	19.	44.	6.1	25.
Chloride	32.	27.	85.	6.3	48.
Hardness, Total as CaCo3	214.	320.	460.	149.	300.
Alkalinity to pH 4.5	182.	280.	377.	133.	236.
Potassium, Total	3.3	3.5	2.1	1.3	1.8
Sulfate as So4	24.	20.	8.5	19.	28.
Solids, Total Dissolved, 180 C	250.	343.	565.	183.	306.
Nitrogen, Kjeldahl, Including Ammonia	15.	15.	0.56	0.090	0.17
Calcium, Total	38.	58.	67.	29.	49.
Magnesium, Total	16.	25.	26.	7.6	16.
Conductivity**	429.	611.	931.	305.	651.
Selenium, Total*	< 10.	<10.	<10.	<10.	<10.
Sodium			41.		
C.O.D.	22.	45.	20.	6.8	7.6
Barium, Total	< 0.5	< 0.5	<0.5	<0.5	<0.5
Arsenic, Total*	12.	< 10.	<10.	<10.	<10.

* results in micrograms/liter
** microhms/centimeter